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News Letter

WASHINGTON 1932
CHICAGO 1933

TO BEGIN work on the program of the 28th Annual Convention in Washington February 23-26, 1932, there will be an important meeting of the Program Committee of the Institute, P. H. Bates, chairman, in Washington, April 13.

Members will be interested in the decision of the Board of Direction to make the next convention a 4-day meeting with several open periods for matters of general interest.

In line with the adoption a year ago of a policy to decide the place of meeting, east, or middle west, with a view to some regular alternation, and the accommodation of the greatest number of members, the Board decided that the 1933 convention will be in Chicago, subject to satisfactory local arrangements.

The Institute's new address is 624 Fisher Building, Detroit — across the street and half a block east of "2970 West Grand Boulevard" where we have been for five and a half years. The Fisher Building location is to be a temporary one—pending the completion (probably in September next) by Fisher interests, and availability of new offices in the New Center Building on Second Boulevard, between Lothrop and Bethune—one block north of West Grand Boulevard, one block west of Woodward avenue, diagonally across Second and Lothrop from the Fisher Building. Until further notice address:

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624 Fisher Building,
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The Milwaukee Convention in Summary

BY D. F. JENNINGS

From the opening by President Duff A. Abrams to the adjournment by Vice-President Arthur R. Lord, chairman of the sixth and final session, every session of the 27th annual convention of the American Concrete Institute held at the Hotel Schroeder, Milwaukee, Wisc., February 24, 25 and 26 was marked by large attendance and keen interest in the program.

The registration, 605, compares favorably with that of preceding years (1927, Chicago, 649; 1928, Philadelphia, 684; 1929, Detroit, 678; 1930, New Orleans, 306.) The mild but invigorating weather and the hearty 100 per cent cooperation of the local committee combined to make the three-day meeting a success. During the six technical sessions nearly forty papers and reports were presented or discussed and while the program might have been considered by a few to be "heavy," being largely concerned with research, the work of the Program committee could be judged by the large and attentive audience at every session, even including the morning session following the annual dinner and entertainment. When the gavel was sounded for final adjournment there was still a good percentage of the chairs occupied, notwithstanding the fact that convention chairs seem to have a way of growing harder after being occupied repeatedly for several consecutive sessions.

To summarize briefly the high points of the convention without following the order of arrangement on the program is difficult because the sessions were all filled with papers and discussions of interest and value to those who attended. Workability, durability, permeability, properties of mass concrete, central mixing, admixtures and aggregates all came up for discussion as did specifications and problems of engineering design and construction. As to slump and flow and workability, the trend of discussion seemed to indicate the need for a more definite understanding of the terms workability, consistency, wetness and plasticity used by the different investigators. An agreement upon a terminology would probably show less disagreement in ideas than in terms as now used.

The Institute convention was preceded by the annual convention of the Concrete Masonry Association, in joint sessions with the Wisconsin Concrete Products Association at the Hotel Schroeder beginning Monday, February 23.

Workability and Admixtures

President Abrams opened the first session of the Institute's 27th annual meeting on the afternoon of February 24. The usual order of convention program was not followed in that the discussion of papers previously published in the Journal comprised the first part of the program.

The three papers, "Admixtures and Workability of Concrete" by G. M. Williams, published in the February Journal, and "A Study of the Flow

Table and the Slump Test" by George A. Smith and Sanford W. Benham and "A Study of Slump and Flow of Concrete" by Inge Lyse and W. R. Johnson, published in the January JOURNAL, were presented by title and followed immediately by prearranged and general discussion.

R. B. Young, as an unprejudiced party, opened the discussion. He confessed that after reading the last two named papers, he was not successful in bringing the statements in the two papers together, and did not agree with the authors in either case.

He referred to the last two papers of the group as being experimental comparisons of flow table and slump as measures of workability and consistency. Using quite similar materials and proportions but different methods of approach the authors of one paper prove the flow test superior to the slump, while the authors of the other paper prove just the opposite. Mr. Young's conclusion was that neither the slump nor flow test is a measure of workability, which he defined as that combination of properties of concrete which allows us to handle and place it with a reasonable amount of labor and a minimum of segregation. While neither slump nor flow measures this, the slump test has been used as a control test in the field and its widespread adoption is proof that it has considerable merit.

Quoting from Smith and Benham to the effect that slump tests act differently with different types of mixtures, Mr. Young considered this a general experience stating the principal value of the slump test to be that with a certain class of concrete a uniform degree of workability is represented by a given slump.

Mr. Young deemed the flow test almost entirely for the laboratory, too cumbersome for practical field use, subject to the same faults as the slump test but usable over a greater range of mixtures.

Mr. Young expressed the opinion that the introduction of admixtures into the tests described in both papers to increase the range of mixtures, would probably have the added effect of producing more discussion than otherwise, although none of the authors was believed to have presented his data to make a case for or against admixtures.

Commenting upon the paper by Professor Williams, Mr. Young quoted from the author's statements, included in the Editor's note in the February JOURNAL, that the purpose was to outline a method of test for the rating of admixtures rather than to discuss the merits or demerits of any particular one or group of admixtures. He referred to the comparison by Professor Williams of cement and admixtures as to volumes of paste given when equal weights are mixed to give pastes of equal flow, also to the effect on the volume of mortar under the same conditions.

Discussion of slump and flow tests by J. C. Pearson was confined to the present status of the workability problem and the possibilities that are suggested by the data in the Smith-Benham and Lyse-Johnson papers, and by experiments carried out in the research laboratory of the Lehigh Portland Cement Co. In Mr. Pearson's opinion the outstanding feature of these two papers is the demonstration that for concrete of different composition the ratio of slump to flow as measured on the flow table is not constant but increases with the richness of the mixtures.

The device used by the discussor for studying the flow-force relations in cement pastes was described as one in which the speed of the mixer drum is analogous to the rate of flow and the reacting torque of the stator blades is the force.

Curves were presented illustrating flow-pressure relations to be expected if a mass of freshly mixed concrete could be forced out of a container through an orifice or a tube in such manner that the rate of shearing flow could be determined under different pressures. After the pressure had reached a certain value the relation of flow to pressure would become linear or approximately so. The degree of ease with which concrete shears and flows depends upon the quantity of paste in proportion to aggregates, and to greater or less extent upon such other factors as grading of aggregates and presence of admixtures.

Mr. Pearson suggested the possibility of development of a simple device by means of which three or more definite applications of force can be made to a mass of concrete and the corresponding rates of flow measured at least in relative terms, disregarding the present slump and flow tests.

George Conahey read a discussion by George A. Smith of the paper by Professor Williams stating that workability involves more than mere care in placing concrete. Though agreeing that segregation plays a large part when studying workability, Mr. Smith found it to be only one factor influencing the placeability of concrete. The item of cost must be given consideration. Suitability for the purpose intended makes the question of workability, a relative one, Mr. Smith stated, citing further that under all conditions work must be done to effect satisfactory placement.

Workability of concrete was stated to be the resultant of two factors: ease of movement of aggregate particles and of small parts of the concrete mass relative to each other, and cohesion within the mass or lack of segregation. Mr. Smith classed as an admixture any addition of material to the designed mix which will influence the placeability or workability in a beneficial way. Additional cement, increased quantity of mixing water, a combination of the two, or some other material of merit may be deemed admixtures.

In conclusion Mr. Smith prophesied an early answer to some of our problems with a definite correlation of ideas and an accepted method of evaluation of the factors governing workability.

A second written discussion contributed by Mr. Smith dealing with the Lyse-Johnson paper, was also presented by Mr. Conahey. In this discussion it was pointed out that in the paper on the flow table and slump test he and his co-author did not have in mind indicating that either test is a measure of workability when concretes of different compositions are considered. The terms "consistency" and "wetness" were used when referring to property or condition. Workability and consistency were not considered synonymous under all conditions.

Mr. Smith voiced the opinion that the two papers dealing with flow and slump have very much in common and when properly interpreted will indicate the same conditions; that the same conclusions may be reached from either paper. Neither test in itself is accepted by the discussor as a criterion, it being contended that the only correlation

between slump or flow and workability is in the case of a given mix. It was further stated that under different and variable conditions, it is necessary to distinguish between fluidity, wetness, or consistency and the workability, and that once this is done we will be in a position to study the effects of various materials and variations in materials on the workability or the placeability of concrete.

Following the presentation of Mr. Smith's paper, Mr. Conahey referred to the numerous pieces of equipment designed for measuring workability or consistency, stating that until recent years, consistency generally referred to the water and the term workability referred to well graded aggregates. In his opinion consistency is now considered to include workability and depends upon the force-flow relation of the cement paste.

W. C. Bruce classified authorities on concrete as "rabid drys" or "wringing wets" and voiced the opinion that the term workability includes plasticity and flowability. He stated that the conclusions drawn by Professor Williams should not be construed as resulting from a complete study of the subject of admixtures.

Prof. A. N. Talbot referred to tests made several years ago varying mixtures and conditions. Slump and flow table measurements were made and richness of mixture varied. It was found that flow did measure the wetness of the mix, for given quantities of cement with a straight line relation for each different degree of wetness. Flow was proportional to the amount of water times the amount of cement in the mix, plus a constant when all mixtures were considered.

A discussion of the papers on the flow table and slump cone and on the slump and flow of concrete written by Donald M. Burmeister, Columbia University, was read by title and will be presented with the discussion in full in the JOURNAL for May.

STUDIES OF CONCRETE MIXTURES

S. C. Hollister presented a very interesting paper in which he cited ten queries arising from experiences in concrete mixing not, in his opinion, explained by the usual concepts of the composition of a concrete mixture during its workable state. This paper appears in its entirety in the *Proceedings* pages of this JOURNAL.

Professor Hollister pointed out that there are two major characteristics by which a concrete mixture is usually judged — its placeability and its strength. The presence of the jelly-like substance surrounding the cement particles has a bearing upon the workability of the mix. A relation was found apparent between volume changes and the richness and wetness of the mix, factors involved in excess colloidal formation. The colloidal substance or gel is tied up to the water-cement ratio, shrinkage, permeability and strength and while in a colloidal stage, with workability.

That the presence of gel around cement is not questioned was emphasized by Prof. W. A. Slater, citing a test wherein a mix of 7 gal. of water per sack of cement was mixed and conveyed for 2½ hours. Analysis of constituents showed an apparent increase in cement and decrease in sand, with a change in slump and increase in strength for specimens taken 2½ hours after mixing.

A STUDY OF WATERPROOFINGS FOR CONCRETE

Results of an investigation at the National Bureau of Standards, Washington, of many different materials used as a means to impermeability in concrete were reported by C. H. Jumper in his paper, "A Study of Waterproofings for Concrete." Mr. Jumper's paper, which will appear in full in a subsequent issue of the JOURNAL, described the design of a concrete which, when subjected to 20 lb. per sq. in. pressure, would give sufficient leakage to measure.

Test specimens were made using various integral and surface waterproofings by the methods recommended by the manufacturers, and plain concrete specimens made for comparison of results. Strength and absorption tests were also made.

A. S. Douglass in discussing the Bureau of Standards tests, referred to more or less similar tests made by the Detroit Edison Co. in which it was concluded that the same money value of admixtures if expended for additional portland cement would give better results.

R. B. Young described his experience with surface treatments to slow down deterioration of "sick" concrete structures. Of the 25 used, few were of value at the end of six months and none was effective after two years, leading to the conclusion by Mr. Young that surface waterproofing is hopeless on structures not of 100 per cent good concrete.

M. W. Meyer referred to the difficulties experienced in simulating in practice the production of laboratory concrete due to the many irregular conditions that present themselves on every concrete job.

In questioning the possible psychological effect of using waterproofing compounds, Arthur R. Lord queried why a waterproofing treatment had actually stopped the flow of water through a previously leaky wall, referring to results within his own experience.

CONCRETING CALDERWOOD TUNNEL

In the absence of W. R. Johnson, author of "The Concreting of the Calderwood Tunnel," his paper was read by title. This illustrated construction story will appear later in the *Proceedings* pages of the JOURNAL.

DIABLO DAM

At the second session, presided over by Vice-President S. C. Hollister, the first paper on the evening program was read by title, "Design and Control of Concrete for Diablo Dam," by Herbert F. Faulkner and R. R. Hubbard. This appeared in the February, 1931, JOURNAL. Neither of the authors was present to discuss the paper and in their place F. R. McMillan who had visited the job in company with the authors, described some of the features which appealed to him as outstanding.

Mr. McMillan considered the dam a unique structure, thin in relation to height. Interesting construction features pointed out were the use of aggregates, none of which exceeded 4-in., and the use of belt conveyors for distribution of concrete. The success of the methods was considered measured by the results, the dam being an excellent piece of construction.

In discussing the possibility of a water film forming around and under large particles of aggregate having a small amount of absorption, and in answer to a question as to the effect

of colloids in preventing water from rising in the concrete, Professor Hollister stated that the colloids would rise with the water.

LONG TIME TESTS OF CONCRETE

Prof. M. O. Withey presented a resume of his paper which appeared in the February JOURNAL on long time tests of concrete at the University of Wisconsin, reporting 20-year results in 50-year and 100-year test series.

In the original program only one set of aggregates and one cement were used, proportions being by weight. The second series of tests (100-year) involves four brands of cement and two coarse aggregates. Compression, freezing and thawing and absorption tests are included in the tests to extend over a century. A continuous gain in strength was noted in the compression tests.

Diagrams not included in the printed paper were discussed and the comment made that difference in test operators and in equipment used were as great as any changes in actual results.

In introducing a discussion of the strength-age relation of modern cements, President Abrams expressed the hope that Professor Withey would report the final tests at the end of the 100-year period. To this Professor F. E. Richart later referred suggesting that Professor Withey follow the example of a Japanese investigator who is also carrying on long time tests and who has provided for the completion of the 100-year program by his son-in-law and grand sons.

President Abrams' discussion, which will appear in the June JOURNAL points out that the rate of reaching a certain strength is an important factor and that the old formula for computing 28-day strength $= \frac{14{,}000}{7^x}$ does not hold for present day strengths of cements. The relation of compressive strength to logarithmic age was found to follow a straight line for certain conditions such as quality and amount of cement. Stiffer mixes depart sooner from the straight line.

Prof. W. K. Hatt's brief discussion of the Withey paper was read by Prof. Hollister. The point referred to was the relation between volume change and loss or gain of water in curing which it was found in tests at Purdue University varied with the richness of the mix. Prof. Hatt's discussion, including a diagram showing curves for this relationship, for gravel, stone and slag concretes will also appear in the June JOURNAL.

PERMEABILITY OF GRAVEL CONCRETE

The results of research begun 3½ years ago, with 34 different mixes, each with varying amounts of water and with each test repeated five times to eliminate discrepancies by operators, were set forth in a paper on "Permeability of Gravel Concrete" by Paul T. Norton and Dan H. Pletta. Mr. Pletta presented the paper at considerable length. It will appear later in the *Proceedings* pages of the JOURNAL.

PROPERTIES OF MASS CONCRETE

The report of committee 108—Properties of Mass Concrete—was summarized by Prof. Raymond E. Davis, author-chairman of the committee and joint author with G. E. Troxell of the report which appeared in the January JOURNAL. Professor Davis made a fine and interesting presentation well within the time allotted by the program committee for his opening discussion, emphasizing the points touched upon in the report concerning the great

amount yet to be learned rather than what is now known about the action inside of large masses of concrete.

The committee, divided into four sub-committees, has done little except to explore the field, the available data concerning, principally, dams. Professor Davis stated that properties of mass concrete where temperatures are high vary widely from those of small masses cured at normal temperatures, the cement paste in large masses developing temperatures 50 to 100 deg. above normal. Since the heat generated within the mass hastens the chemical process of hardening, increasing the early strength, and since later strength of concrete cured at normal temperatures surpasses that cured at high temperatures, a type of cement having low heat generation would be desirable, to avoid large residual stresses in mass concrete.

Tests of mass concrete are to be made in the field, and also the making and testing of specimens of unprecedented magnitude containing 5 to 50 cu. yd. concrete are planned by the committee.

Prof. Hollister, in emphasizing the importance of the research in mass concrete, pointed out that Professor Davis is one of five consulting engineers in connection with the Hoover dam in which it is planned to place continuously 6000 cu. yd. concrete per day for approximately 500 days.

DURABILITY OF CONCRETE

In introducing F. R. McMillan and R. B. Young as the two participants in the symposium on durability of concrete, A. E. Lindau, chairman of Committee 801, stated that their work has been going on for some time and is likely to continue for a still longer period, examining structures from the sub-arctic regions of Canada to the subtropics of the United States, making the job of the committee a big one geographically.

F. R. McMillan outlined the work of the committee in examining more than 700 structures, more than half of which he has seen personally. All information collected is to be summarized and digested. Besides examination, responsible people are interviewed concerning each structure and where possible original records are studied. The principal source of information, Mr. McMillan stated, is the structure itself and he directed attention, for those who have opportunity for such studies, to outstanding elements of diagnosis which experience had taught him to look for.

R. B. Young, particularly interested in the work of committee 801 because of his connection with the Hydro-Electric Power Commission of Ontario, with very large amounts of concrete (some good and some bad, according to Young) stated that in general, concrete is functioning satisfactorily. Most of the defects are believed to be due to faulty workmanship, and although to unsound aggregates was attributed trouble in a few instances, cement was seldom the primary cause of disintegration.

Mr. Young's conclusion was that water solvent action destroys concrete by dissolving cement and that concrete should be so dense that water can not enter. He further pointed out that lean concrete, no matter how strong, may not be durable, that strength can not be taken as a measure of durability.

The papers by Mr. McMillan and Mr. Young together with convention discussion will appear in a later issue of the JOURNAL.

SHRINKAGE OF CONCRETE MASONRY

D. R. Collins, President Concrete Masonry Association, was chairman of the third session.

P. M. Woodworth summarized conclusions from further tests on shrinkage of concrete masonry, his investigations being a continuation of tests reported by W. D. M. Allan at the 1930 convention. Conclusions reached include the following: Use of air dry units reduces shrinkage of wall to 20 to 30 per cent of that of saturated units; air curing units for 26 days reduces to a minimum the amount of shrinkage; high pressure steam curing results in shrinkage only 50 per cent of that of moist or low pressure steam cured units. As the use of air dry units will practically eliminate shrinkage in the wall, Mr. Woodworth recommended keeping units dry after delivery on the job.

Discussion brought out the point that expansion—the reverse of contraction—is tied up with the mortar used in the wall; that mortar joints of $\frac{3}{8}$ in. give minimum shrinkage; that 1-in. joints result in several times as much shrinkage.

CONTINUOUS AND BATCH MIXERS

Benjamin Wilk presented "A Comparison of Continuous with Batch Mixers in Plant Operation," (February JOURNAL) in which he stated the different reasons for which each type of mixer is favored. At the plant where the experiments were carried on, concrete was mixed at the rate of 4 cu. ft. per minute and Eberling continuous and Blystone batch mixers compared.

The variation in strength of blocks from the two types of mixer was reported as very small, and there was practically no difference in the yield with the two types of equipment.

The tests were made more as a commercial comparison than a laboratory investigation and pointed to possibilities of factory economy.

COLOR IN TROWELED CONCRETE SURFACES

In announcing W. D. M. Allan's report as chairman of Committee 408 on a proposed "Recommended Practice for the Use of Color in Troweled Concrete Surfaces" Chairman Collins recalled to the minds of those who attended last year's convention at New Orleans, the somewhat novel color schemes which were being worked out in sidewalks of that city. He complimented Mr. Allan on his committee activities.

Mr. Allan outlined the principle classes of color materials as pigment admixtures, selected aggregates, chemical stains and water and oil vehicle paints. It was a task, he reported, to get agreement because of the different opinions and lack of test data regarding pigment admixtures which is the basis of the committee's first report. The progress report includes: (1) Specifications; (2) recommended practice; and (3) an appendix to furnish a laboratory—procedure for testing mineral pigments. It is presented in full in the *Proceedings* pages of this issue of the JOURNAL.

Considerable discussion was centered around the possibilities of obtaining uniform color in concrete surfaces and the suggestion was made that cement be furnished with color ground into it to overcome the difficulty of accurate measurement of the finely ground coloring materials.

MANUFACTURE OF CONCRETE MASONRY UNITS

A proposed recommended practice for the manufacture of concrete

masonry units to bring a statement of preferred practice up to date was presented for discussion and not for adoption at the convention, by P. M. Woodworth, chairman of Committee 708. The recommendations cover in general plant layout, materials and operation.

Criticism of the report, which appears in this issue of the JOURNAL, is desired by the committee.

CAST STONE STANDARDS

The Institute's specification for cast stone adopted as tentative 2 years ago was followed by its adoption by the Cast Stone Institute. Certain changes in this tentative specification recommended by the committee were discussed by Fred Weigel, committee chairman. These provisions were not released far enough in advance of the 1931 convention to permit their tentative adoption at this time but with their publication in an early issue of the JOURNAL, opportunity for full discussion will be given.

As a result of the tests carried out the last two years considerable information has been accumulated on practical and mechanical aspects of testing procedure. Among the items given consideration are preparation of the 2-in. cube for compression test specimen, the manner of testing, and developing a new absorption test.

BURIAL VAULTS

C. A. Wiepking, member of Committee 709, presented the committee's progress report on the subject of burial vaults, referred to as not a cheerful one, but "less dismal if we may be confident of the quality of the tomb." The committee, organized in January, this year, had not had time to present a tentative specification for adoption. The progress report which includes suggested specifications for designing and testing concrete burial vaults was put on record with the view to drawing discussion from morticians and vault manufacturers on the provisions of the specification and the possibility of enforcement. Watertightness and absorption of the concrete and strength of the vault as a unit are considered of prime importance. Discussion of the report, which will appear in full in a later JOURNAL, is invited by the committee.

Concluding the morning session, Chairman Collins appointed J. C. Witt and Benjamin Wilk as tellers to count the ballots cast for officers and directors.

ROADS

The fourth session Wednesday afternoon devoted to consideration of aggregate sizes, mixing and central concrete plants was presided over by T. Chalkley Hatton, president Engineers' Society of Milwaukee. Three of the contributions presented were descriptive of interesting studies in connection with road construction under the title, "Field Practices in Using Concrete Aggregates in Multiple Sizes" and, although all concerned the same work in Wisconsin, the conclusions arrived at were somewhat at variance.

T. C. Thee, U. S. Bureau of Public Roads, presented at considerable length his paper describing several highway construction jobs with their plant layouts for handling aggregates in separated sizes. Variations within a batch are hard to eliminate regardless of the size of the batch or length of mixing time after all the solid materials are in the drum. The author in predicting a low limit for the extent to which the use of separated sizes of coarse aggregates can be pushed, found the cost likely to increase progressively as the

variations from batch to batch are reduced.

A. L. Hambrecht's contribution reviewed the old order of equipment used on concrete pavement and referred to old methods of proportioning, resulting in widely varying consistencies and qualities. He compared two projects, one using a single coarse aggregate, another separated sizes and found the latter gave more uniform results. He concluded that the closer control can add materially to quality and uniformity of quality, while uncontrolled variations within a single batch put a limit on the degree of refinement which is desirable.

George W. Langley considered the theories of the design of concrete mixtures from a materialistic viewpoint because of his responsibility to the taxpayers in his county. Mr. Langley found it evident from his records that close control of the aggregates makes possible a considerable saving in cost. He questioned Mr. Thee's conclusion that the use of only two sizes of coarse aggregate is sufficient, suggesting the possibility that continued use of 3 sizes of coarse aggregate, with more efficient equipment and methods, may give further benefits, and economies.

CHARACTERISTICS OF CONCRETE IN THE MIXER

The presentation of the first two papers of Wednesday's second session consumed considerable time in excess of that allowed for in arranging the program, thereby precluding any convention discussion on the subject, and Chairman Hatton introduced the next speaker, Professor Emory D. Roberts, whose subject was "Determining the Characteristics of Concrete in the Mixer." The chairman cited the studies of Milwaukee manufacturers of concrete mixers, who had approached the subject of measuring workability from a different viewpoint than was discussed in the Tuesday afternoon meeting.

Professor Roberts prefaced his presentation by the statement that he was not a party to the previous discussion on workability. In his paper which he read in full, he described the apparatus designated as the consistency indicator, and its operation. Curves were presented representing the consistency of the concrete in the mixer.

Discussion which followed the description of this new equipment brought out the fact that while it is now in the experimental stage as a part of a paver, "mixometers" are in use at present on the western coast on other types of mixing equipment.

CENTRAL CONCRETE PLANTS

A new progress report of Committee 603* was presented by Frank I. Ginsberg, the committee's author-chairman, outlining the progress in design and operation of central concrete plants. Realizing that there is considerable additional information to be developed, particularly on various vehicles and bodies used in the transportation of concrete, and that some radical developments are taking place in the field, the report was intended merely to stimulate interest and discussion. Although the report, which will be printed in full in a later issue of the JOURNAL, is not intended as a complete report and additional data on the subject will be submitted to the Institute

*The first progress report of Committee 603, Design and Operation of Central Mixing Plants was presented as a symposium by committee members at the 1930 convention. See *Proceedings*, Vol. 26, p. 551. Since that time, through a frequently published error this committee has been erroneously designated as 602. The report will be published as 603—in agreement with the 1930 report.—EDITOR.

later, it represents a logical, forward unifying step from the symposium by members of the committee last year.

SPECIFICATIONS FOR READY MIXED CONCRETE

Specifications for ready-mixed concrete originally proposed by Committee 504 were published in the November, 1930, JOURNAL. Miles N. Clair, author-chairman reported that the proposed provisions of the specification had been modified on February 25, 1931, to meet the objections of members of the committee. In reviewing the proposed specification and the work of the committee, Mr. Clair proposed a modified statement that changes in proportions may be made at the direction of the architect and engineer concerned, and also as to the measure of volume of the concrete.

The proposed specification, with amendments allowing an elapsed time greater than one hour before placing the concrete in the forms, under certain conditions as determined by the architect or engineer, and permitting slumps greater than 6 in. for centrally mixed concrete, in re-mixing type trucks, if tests show no segregation, was advanced to a tentative standard by vote of members of the Institute present.

PLASTIC FLOW

The fifth session—the morning of the last day of the convention—was devoted to time-deformation of concrete, to work of the column test committee and building construction specifications. It was presided over by Past President A. E. Lindau, self-styled traffic officer to regulate the traffic—papers and discussion—according to the time schedule of the program. In announcing the first discussion, by Prof. Raymond E. Davis on flow of concrete under the action of sustained load, Mr. Lindau stated that the information available about concrete is almost overwhelming, structures now being built that were not thought of a few years ago. The Hoover dam was again cited as an outstanding example.

Professor Davis touched only the high points in discussing his paper prepared in conjunction with Harmer E. Davis and published in the March, 1931, JOURNAL and reporting a part of the work assigned to Committee 109. He preceded his discussion by reference to the banquet and entertainment the previous evening (the 27th annual dinner of the A. C. I.) graciously offering to pardon any member of his audience who should fall asleep and asking in advance the same consideration should he fall asleep himself. The discussion of flow of concrete, which he stated has been known to exist for 25 years, dispelled any tendency to slumber on the part of the large number in attendance.

Professor Davis reviewed the synopsis pointing out that the paper which presents the results of tests on plain and reinforced concrete to determine the effect of sustained loads upon the deformations and upon the distribution of stresses in concrete and steel, is divided into two parts. One concerns laboratory tests at the University of California in the interval 1925-1930, and the other summarizes the published results of the more important tests reported by other investigators during the past 25 years, discussing time-yield, plasticity, time-deformation and plastic flow.

Two formal discussions of the Davis paper followed, one by Professor G. A. Maney and one by Lars Jorgensen

which will appear in the June JOURNAL. Professor Maney emphasized the importance of the relation between shrinkage and plastic flow. He described his experiments with solid and hollow companion cylinders to determine the relation between time and shrinkage. The need of plain concrete specimens for shrinkage control was demonstrated.

In the absence of Lars Jorgensen, Professor Davis presented his brief discussion by title. Mr. Jorgensen stressed the point that in the design of arch dams the sustained modulus of resistance must be used rather than the instantaneous modulus of elasticity.

Prof. J. R. Shank presented some interesting data obtained under different conditions of materials and procedure. The tests included determining the effect of the use of widely differing aggregates, the effect of load on plastic flow and bond flow or shear flow in the splices of bars in compression members. Experiments with natural stone showed no plastic flow under sustained load.

DESIGN FOR HURRICANE EXPOSURE

One of the destructive elements not peculiar to concrete alone—wind stress—was discussed to considerable length by Albert Smith, author-chairman of Committee 308. Mr. Smith based his discussion on numerous excerpts from his paper, "Design of Concrete Buildings for Hurricane Exposure" printed in the March JOURNAL, as part of the work of his committee.

REINFORCED CONCRETE COLUMN INVESTIGATION

Progress of Committee 105 on Reinforced Concrete Column Investigation was noted in progress reports and papers in both the February and March JOURNALS this year, by W. A. Slater and Inge Lyse dealing with the tests made at Lehigh University, and by F. E. Richart and G. C. Staehle describing the investigations at the University of Illinois. These reports were summarized briefly first by Professor Slater, chairman of the committee and then by Professor Richart.

In announcing these items on the program, Chairman Lindau explained the circumstances under which the column tests were started, crediting to F. R. McMillan the initiative in his insistence that there were many factors in reinforced concrete columns about which more should be known.

Professor Slater reviewed the object of the tests, the program being carried out, and cited the importance of adopting a specification for reinforced concrete columns in which account is taken of the flow of concrete under load.

Professor Richart summarized the results of the tests at the University of Illinois pointing out the importance of the duplicate tests at the two universities. The results thus far obtained indicate that final results of the investigation will have a very definite bearing on the proper method of reinforced concrete column design.

In order to keep his program traffic moving according to schedule further informal discussion of the column tests was precluded by Chairman Lindau. Professor Maney read a brief discussion pointing out that the data obtained from the column investigation brings about the realization that from 50 to 90 per cent and in many cases, all of the column load is carried by the vertical steel alone. This leads to the suggestion of a new type of column with greater percentages of vertical steel

and much higher elastic limits in the vertical steel. The importance of the use of the control or companion specimen of plain concrete to determine shrinkage under no load was emphasized as an important factor in separating the effects of shrinkage and plastic flow.

TENTATIVE CONSTRUCTION SPECIFICATIONS FOR CONCRETE WORK ON ORDINARY BUILDINGS

Arthur R. Lord, Chairman of Committee 502, referring to the proposed construction specification adopted tentatively as 502 T-30 at the 1930 convention and subjected to considerable later discussion, proposed an amendment to article 10 concerning admixtures. This amendment, which would permit the use of admixtures, test reports of which show no harmful results to the concrete, was agreed to at a meeting of the committee the previous evening with representatives of the manufacturers of admixtures present. Mr. Lord termed the amendment a change from a red stop light to a yellow warning light, putting the use of admixtures up to the architect and engineer. Another change in the specification, designed to permit the use of bulk cement, was proposed by the committee. It was voted to continue the amended specification as tentative for another year—502 T-31.*

SUPPLYING, FABRICATING AND SETTING REINFORCING STEEL ON ORDINARY BUILDINGS

William F. Zabriskie, author-chairman Committee 503, reviewed the requirements set up for the specification for supplying fabricating and placing reinforcing steel on ordinary buildings. Upon his motion, the specification was adopted as tentative—503 T-31. The original draft of this specification was preprinted in the February, 1930, JOURNAL.

CONCRETE WORK ON THE SMALL JOB

The report of Committee 506, Arthur R. Lord, author-chairman came before the Institute for consideration the first time since publication in the September (1930) JOURNAL. Mr. Lord stated that full discussion by every member of the committee had led to revisions limiting the maximum size of aggregate to 1 in. unless larger size is directed by the architect or engineer in charge. An addition to article 10 was proposed providing that when the concrete mix is determined by means of preliminary tests made by an approved laboratory and using the same materials as are to be used in the work, the water-cement ratio to be used in the work shall be taken as that giving a strength under standard laboratory conditions, at the age at which the concrete is to be put into service, not less than 15 per cent greater than the ultimate strength required of the concrete in the work. The report, as amended, was adopted as a tentative specification of the Institute.—506 T-31.*

NEW OFFICERS

Vice-President Arthur R. Lord's remarks in opening the last session of the convention reminded the unusually large audience for a final session, that he was from Chicago and intended, as chairman, to live up to the city's reputation, so far as the substitution of a 10-cent-store hammer for the usual sawed-off shot gun would permit. With hammer, in lieu of a lost gavel, he would terminate the remarks of speakers who threatened to exceed their established time limit.

The tellers appointed the previous day reported on the canvass of the

*Amendments will be published in the JOURNAL for May, 1931.

ballots for officers and directors of the Institute as follows:

President, Duff A. Abrams; Vice-President, S. C. Hollister; Treasurer Harvey Whipple;* Directors, 3rd District, J. C. Pearson; 4th District, P. H. Bates; 5th District, F. R. McMillan.

Following the declaration of the reelection of Duff A. Abrams, the president delivered a very interesting address naming "research" as the key note of the Institute's future activities. The president's address appears in full in the *Proceedings* pages of this JOURNAL issue.

AMENDMENT TO BY-LAWS

An amendment to the by-laws with respect to the election of a nominating committee as outlined in the News Letter section of the JOURNAL for December, 1930, was adopted and referred to letter ballot.

CINDERS AS CONCRETE AGGREGATE

Heeding the chairman's previous announcement that three strokes of the hammer-gavel meant that the speaker would be "through," Einar Christensen proceeded with a very able synopsis of his report, as author-chairman of Committee 203 on "Cinders as Concrete Aggregate" (February JOURNAL) finishing after the warning stroke but before the time for the three-stroke finale.

Mr. Christensen said that light weight concrete is here to stay, as is evidenced by the fact that large buildings including the Empire State and Chrysler buildings in New York used a large amount of cinder concrete and were built before the cinders report was made. Cinder concrete, at first considered a step-child of the concrete industry is advanced by Mr. Christensen for use in job-made and shop-made concrete. The summary included reference to the apparent need for more research.

Of the four discussions of Mr. Christensen's report which had been prepared, three were read by title in the absence of the authors, and will be published with other discussion in the JOURNAL for June.

L. E. Pitner referred to but did not describe the Cincrete special processing of cinders as used in manufacturing cinder building units in Milwaukee. He pointed out that variations of over 100 per cent in coke content and proportions of coarse and fine materials are found in cinders from different plants or at different times from the same plant. Claiming that the properties of the blocks such as absorption and insulation vary with the properties of the cinders he stated that it was the quality of the cinders which makes the architects swear by or at cinder concrete. Mr. Pitner protested against the report of Committee 203 in its present form and also recommended that a code be established designating a standard form of nomenclature applying to concrete of various weights.

BURNED CLAY AND SHALE AGGREGATES

In introducing the report on burned clay and shale aggregates, chairman Lord mentioned various names by which these products are known, including Haydite, Lytag, Corlite, Cel-Seal, Pottsco and Waylite. The report of George E. McIntyre, author-chairman of Committee 204, was given as an informal outline of the committee's efforts which to the present time have been concerned largely with Haydite, as commercially available on a considerable scale.

*The Board of Direction also reappointed Mr. Whipple Secretary.

The function of the committee, Mr. McIntyre stated, was interpreted as dealing with aggregate produced as such and not as a by-product of the clay and shale industries. Stating that research regarding Haydite has not been correlated, he added that Haydite is made from almost any kind of clay or shale in a rotary kiln with any fuel, and that it has the same qualities no matter where it is made, except local characteristics which may be adjusted. Mr. McIntyre announced further work to be done by the committee toward correlating available results of research.

CONSTRUCTION AND DESIGN FEATURES OF HAYDITE CONCRETE

Prof. F. E. Richart discussed briefly the paper on construction and design features of Haydite concrete, published in the October, 1930, JOURNAL and on tests of bonding floor finish to slabs of Haydite and gravel concrete, in the December JOURNAL, both of which he prepared in cooperation with V. P. Jensen.

The properties of Haydite were reported to differ from any other material used. Absorption was found to be greatest with the smaller rigid particles until cell sizes were reached and then there was less absorption. The modulus of elasticity was found to be lower for Haydite concrete than for gravel concrete. In beam design the neutral axis is lowered providing for greater compression above. In the bonding of Haydite topping to gravel concrete no appreciable difference was noted when compared with other materials.

LIGHT WEIGHT CONCRETE IN BUILDINGS

Frank A. Randall presented his report (preprinted in the March, 1931 JOURNAL) as author-chairman of Committee 406, Use of Light Weight Concrete in Buildings. Discussion brought out the information that very little difficulty was experienced in placing light weight aggregate concrete. Different contractors varied in their attitude towards the light weight material but difficulties arising were readily adjusted.

DESIGN AND CONSTRUCTION OF DETROIT RESERVOIR

The unusual features of a 20-million gallon reservoir in Detroit were described by Arthur B. Morrill to appear in full in the *Proceedings* pages of a later JOURNAL. Construction of reservoir walls of the size involved, without expansion joints, and the quality of the job as indicated by low leakage measurements were especially noted.

USE OF CEMENT IN BULK

Considerable difference of opinion as to the advisability of using cement in bulk was evident in the discussion following Herbert Coffman's report on the investigations along that line by Committee 607. Summarizing his paper, Mr. Coffman recalled that cement was first shipped in barrels, then in cloth and paper packages and now the deliveries in bulk are rapidly increasing with increasing use of aggregates proportioned by weight, the use of cement in bulk is becoming more economical.

At the cement manufacturing plants provision for handling bulk cement shipments includes pumps and belt conveyors. Equipment for shipping and receiving bulk cement was reported as becoming standardized. It was concluded that the use of bulk cement is economical, simplifies the work and eliminates waste.

H. F. Thomson stated that after two years of operation of two central mixing plants using bulk cement and two using sacked cement, he questioned the advisability of using bulk cement, various factors having to be taken into consideration. Cement for state work may be furnished by the State, odd batches may be required, and a clear record of the identity of the cement may be necessary, all of which requirements are not met by present arrangements at central plants using bulk cement. In reply Frank I. Ginsberg stated that the tendency around New York City has come to favor pretty generally the use of bulk cement.

THE ANNUAL DINNER

The 27th annual A. C. I. dinner on the evening of February 27 with the cooperation of the Engineers' Society of Milwaukee and Associated General Contractors of Milwaukee, provided good food and entertainment.

Toastmaster T. Chalkley Hatton, president of The Engineers' Society of Milwaukee, called upon Professor Duff A. Abrams, President of the American Concrete Institute who made a brief address on the subject "In Twenty-Five Years," recalling progress of knowledge about concrete in the quarter century since the Institute held its 2nd annual convention in Milwaukee.

I. E. Burks had made his second annual trip from Kenogami, Quebec to the Institute convention, this year to receive the Leonard C. Wason Medal "for the most meritorious paper before the Institute at its 1930 convention"—"Concreting Methods at the Chute a Caron Dam."

"Opportunities of Transportation" was the theme of the address by Col. Carl R. Gray, Jr. vice-president and general manager of the Chicago, St. Paul, Minneapolis and Omaha Railroad. Col. Gray outlined his views on the relationship of buses, airplanes and water transportation to the railroads, particularly the pioneer systems, and proclaimed existing unfair regulative discrimination against the railroads.

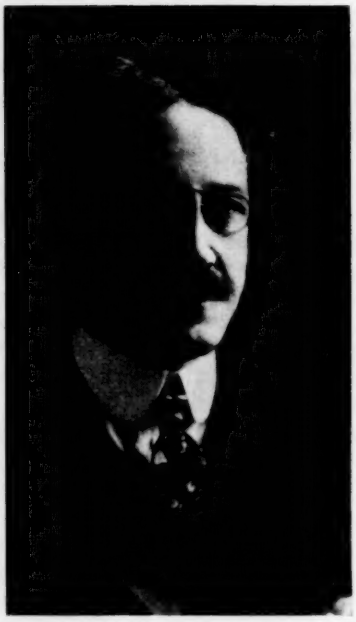
Music by the Erich Schmall Trio, vocal solos, and character dancing were interspersed with the after-dinner speaking and after a very interesting half-hour entertainment by Bockewitz at his easel with his cartoons and lighting effects illustrating poetry recited as he worked with crayon, the main ball room, in which the dinner was held, was cleared for dancing to music by the Milwaukee Yacht Club orchestra.

The dinner—attendance 370—with its entertainment and dancing was a brilliant affair for which, as with all other local activities at the convention, the Milwaukee Convention Committee was largely responsible. The presence of a large number of ladies assured the pleasant success of the dancing until midnight.

SIDE TRIPS

Side trips between sessions of the convention were arranged to numerous industrial plants and construction activities in and around Milwaukee. Points of interest on these trips included plants for the manufacture of machinery and equipment used in the cement and concrete fields, ready-mixed concrete plants, reinforced concrete grade separation structures, buildings, and such engineering work as the U. S. Breakwater, Lakeside Power Plant, Milwaukee County super-highway and Milwaukee sewage disposal plant.

*Fellows of the Institute**



2—Henry C. Turner

The professor of astronomy who addressed us at Philadelphia, was much surprised at our numbers. He had thought that all the concrete work was done by Henry Turner. Other folks thought so, too. A few years ago you could not read a New York newspaper without meeting the slogan, *Turner for Concrete.* The mailman struggled in with a big picture of *Turner City,* an industrial community about the size of Boston or St. Louis, all built by Turner Construction Co. in the preceding year. Figures, with too many ciphers to remember, expressed the contract prices received for this work. But now, even those totals are too small. It is no longer Turner for Concrete but Turner for all kinds of construction.

Henry started out when most of us —including concrete itself — were studying reading, 'riting and 'rithmetic. While no one can exactly remember the time when Turner was a small contractor, he must have started small. He gathered around himself an ever-growing group of keen young men, agreeable, aggressive and untiring, copying faithfully the winning qualities of their leader. Soon the business required subdivision to use effectively so much talent. Instead of permitting his best lieutenants to go out and establish competing companies, Turner split up like an amoeba, created seven fully equipped and manned construction companies all under the same name, competing keenly between themselves and with everybody else. And totals, expressed in dollars or in cubic feet or in customer satisfaction, continued to climb skyward.

When the United States entered the World War most of us dropped our tools and rushed away to enlist, to do our bit, without hesitating and without thinking very deeply. Henry was well over the draft age, but he was no less determined to do his bit on his usual lavish scale. He held his hot heads in check, offered the collective services of a famous building organization. It was

*A special order of distinction to which nominations are made from among his friends and associates in the Institute work by the author of a series of biographical sketches, of which this is the second.—Editor

accepted, tremendously used as a war unit at home, and no breath of scandal was ever raised. It took an elaborate book to picture the *Turner War City*.

Such facts and figures are meaningful not so much in themselves as in the revelation they afford of the magnitude of the motive force behind them. They tell of a man who thinks straight, and who, having decided, moves directly, steadily, almost I had said stubbornly, to the appointed goal. Should others suggest a deviation, Turner simply does not hear. But even that is not an adequate explanation. Meeting a man for the first time one is generally neutral, hopeful but not too expectant of what the new acquaintance may offer, as ready to disapprove as to like. Henry disarms neutrality. He very evidently likes you, sees in you the possibilities of satisfying friendship, perceives in you those qualities that you like to believe are truly there although not worn on the sleeve. This is not so much said as felt. You are drawn to him, you respond as Swedish ore to a magnet. A sound, enduring simplicity of taste throws down any fancy of the usual barrier that wealth and achievement usually build. And you not only instinctively like him—you just naturally feel the urge to have him do something for you, to turn over all your building work into hands so obviously capable, so entirely trustworthy. That's just what a lot of business tycoons do regularly, have done for thirty years in steadily increasing numbers. It makes you think better of yourself and of your kind to see such spontaneous and affectionate trust so long maintained in this skeptical, untrusting world.

While Henry likes persons he doesn't much care for people, for conventions and huge assemblies. He became President of the Institute reluctantly, when it was at the lowest ebb tide in its history. He applied his usual business methods, turned the prow back to the high seas of adventure and usefulness, made the job possible for his successors. For years he entertained the Board at its Fall meeting at his Skyland Farm in Pennsylvania's Poconos. He was firm even with his friends; he did not spoil them. Each director made his own bed, left the blankets and pillows *just so* on departing. He established the Turner gold medal for sages like Talbot, Hatt and Turneaure—who don't need it. That is the only mistake with which I charge him. He should have labeled it for up-and-coming youngsters who now have to struggle along with bronze. There are many more of us.

—ARTHUR R. LORD.

THANK YOU, MILWAUKEE

THE following is from minutes of the Board of Direction:

"On motion duly made and unanimously approved the Secretary was authorized to convey the deep appreciation of the Board of Direction of the American Concrete Institute to the members of the Milwaukee Convention Committee for their splendid cooperation in the work of making the Institute's 27th annual convention an unusually successful one—cooperation which was concerned not only with thorough-going advance preparations but with numerous details during the period of the meetings, involving a responsibility as true hosts which the members of the Milwaukee Convention Committee discharged graciously, generously and thoughtfully."

I. E. BURKS

I. E. BURKS, Kenogami, Quebec, whose 1930 Institute paper, "Concreting Methods at the Chute a Caron Dam" won him the Leonard C. Wason medal for the year's "most meritorious paper," had his interests drawn to the control of quality in concrete soon after his return from France, where he served as First Lieutenant of the 12th Engineers, United States Army. He became chief inspector for the City of Colorado Springs which was just launching a considerable program of paving and public improvement, in which concrete was the principal material. For two years he made a good many tests in support of good practice in proportioning concrete mixtures by the "fineness modulus method" of applying the principle of the water-cement ratio and then he moved on to become resident engineer on concrete pavement construction for the New Mexico Highway department, which with large yardage of concrete going into highways, had no laboratory facilities for testing materials, except as contracted for with commercial laboratories in El Paso and Denver, to comply with Federal State Aid requirements. Burks found that slow and inconvenient and soon "got together a 'tin can' laboratory" of his own on each project. These makeshift efforts attracted the favorable attention of the State Highway Board and the State Engineer. Then came an appropriation for a modern highway laboratory and Burks had the fun of selecting, buying and installing the necessary equipment. This laboratory was operated jointly by the State Highway Department and the State College of Agriculture and Mechanic Arts with Burks in charge as Chief Engineer of Tests and Materials—and Associate Professor, instructing a senior class in "Materials of Engineering."

From that, in 1925, Burks joined the construction forces of the Aluminum Company of America and has since supervised concrete construction on the Santeetlah, Calderwood and Chute a Caron dams and on various other company undertakings.

INSTITUTE BOUND VOLUMES

THE INSTITUTE issues annual bound volumes of *Proceedings* on special order only.

The Institute will accept standing orders (from members only) for the 1932 and subsequent volumes at the additional charge of $3.00 until further notice. The regular member price for a bound volume when not ordered in advance is $6.00. That is the price now applying to Vol. 27 to be completed June 1931. The non-member price is $12.50 per volume.

NEW MEMBERS

SEVENTY-ONE applicants for membership in January and February 1931, have been approved by the Board of Direction as follows:

IN JANUARY

American Vault Co., 747 Henry St., Brooklyn, N. Y. (F. H. VanNess)

Balf Co., The Edward, 171 State St., Hartford, Conn.

Begg, R. B. H., Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va.

Brounell, Parker J., Bingham, Maine.

Clough, G. C., c/o Fred T. Ley & Co., Inc., Springfield, Mass.

Dept. of Street Railways, St. Jean & Shoemaker Aves., Detroit, Mich. (P. A. Kerwin)

Eagle Chemical Co., 414 So. 3rd Street, Milwaukee, Wisc. (Charles Schrank)

Fritz Co., C. B., 138 N. Francis St., Madison, Wisc. (N. J. Schmitz)

Garrett, W. S. c/o Beauharnois Construction Co., Beauharnois, Que., Canada.

Gulick-Henderson Co., 19 West 44th St., New York, N. Y. (Frank L. Greenfield)

Hahn, Harold S., 2018 E. Greenwich Ave., Milwaukee, Wisc.

Heidenreich, Jr., E. Lee, 252 Water St., Newburgh, N. Y.

Holz, Herman A., 167 East 33rd St., New York, N. Y.

Howell, C. H., c/o The J. G. White Engineering Corp., 2A. San Juan de Letran 24, Mexico, D. F., Mexico.

Hutton, S. E., 1542 17th Ave. No., Seattle, Wash.

Kao, P. K., 225 Ridgedale Road, Ithaca, N. Y.

Kohli, T. N., Dhakpuri, Alwar City, Rajputana, India.

Lehner, Walter J., Ullrich Bank Bldg., Mt. Clemens, Mich.

Mackie, Thos. W., c/o Morrow & Beatty Ltd., Fitzroy Harbor, Ont., Canada.

Minnesota Mining & Mfg. Co., Forest & Fauquier Sts., St. Paul, Minn. (L. A. Hatch)

Mitsch, John D., Massachusetts Inst. of Technology, Cambridge, Mass.

Orozco, J. Vincente, Estacion La Cruz, Chihuahua, Mexico.

Pittsburgh, City of, Department of City Transit, 906 County Bldg., Pittsburgh, Pa. (Winters Haydock)

Quebec, City of, City Hall, Quebec, Que., Canada (Edouard Hamel, Ch. Eng.)

Robb, Charles G., Safe Harbor Water Power Corp., Safe Harbor, Pa.

Rolfsen, O., Notodden, Norway.

Stelley, Harry A., Foot of Hertel Ave., Buffalo, N. Y.

Twine, G. J., Queensland Cement & Lime Co. Ltd., 129 Creek St., Brisbane, Australia.

Weatherbee, L. B., c/o The Cooksville Co. Ltd., 25 Queen St. E., Toronto, Canada.

Whelan, Frank G., 70 Claymoss Road, Brighton, Mass.

White, C. J., Experiment Engineering Bldg., University of Minnesota, Minneapolis, Minn.

McKenzie, A. H., Griffith-McKenzie Bldg., Fresno, Calif.

Thomson, Gordon, Experimental Engineering, University of Minnesota, Minneapolis, Minn.

Slack, Searcy B., Bridge Engr., State Highway Dept., East Point, Ga.

IN FEBRUARY

Associated Factory Mutual Fire Ins. Co., 184 High St., Boston, Mass. (C. K. Stiff)

Barrow, A. C., Box 2226, Auburn, Ala.

Burns & McDonnell Engineering Co., 406 Interstate Bldg., Kansas City, Mo. (C. S. Timanus)

Cisneros, Raul, Avenida Colon 150, Cordoba, Argentina.

Clicquennoi, I. M., 204 Wisconsin Ave., Milwaukee, Wisc.

Detroit Bureau of Government Research, 51 W. Warren Ave., Detroit, Mich. (Harrington Place)

Dube, Charles, 32 Cherrelyn St., Springfield, Mass.

Cement Co., Edison, New Village, N. J. (George C. Wilsnack)

Eberling, C. M., 6109 Franklin Ave., Cleveland, Ohio.

Evans, L. T., Apt. 15, 3634 Edwards Road, Cincinnati, Ohio.

Fonseca, Humberto da, Excriptorio Technico da 5a. Divisao, Sorocabana Ry., Sao Paulo, Brazil.

Hartford, City of, Dept. of Building, 550 Main St., Hartford, Conn. (Philip A. Mason, Bldg. Supervisor)

Hirth Concrete Breaking Co., 727 W. Chambers St., Milwaukee, Wisc. (G. W. Hirth)

Hoerr, Philipp J., 1104 Frye Ave., Peoria, Ill.

Koepke Bros. Construction Co., 201 E. College Ave., Appleton, Wisc. (G. W. Koepke)

Kolinski, M. C., Pres., Kolinski Ready Mixed Concrete Co., 127 S. 11th St., Milwaukee, Wisc.

Kreidler, Carl L., Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

Larson, Guy H., Materials Department, Wisconsin Highway Comm., Madison, Wisc.

McGrew, Jr., E. J., Baily-Davis Corp., 141 Broadway, New York N. Y.

Mitchell, Thos. H., c/o The H. K. Ferguson Co., Marunouchi Bldg., Tokyo, Japan.

Morrow & Beatty Ltd., Fitzroy Harbour, Ont., Canada. (J. S. Beatty, V. P.)

Paolini, Alfred J., 263 Hickok Ave., Syracuse, N. Y.

Paul, Frederick T., 203 City Hall, Minneapolis, Minn.

Parkinson, G. W., Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

Perfected Burial Vault & Cement Products Co., 2506-10 Irving Pk. Blvd., Chicago, Ill. (H. A. Dahlquist, V. P.)

Riesen's Sons Co., Paul, 2660 N. Humboldt Ave., Milwaukee, Wisc. (Louis F. Renter, Jr.)

Robertson, R. R. Sidney, Montana.

Schmitt & Son Inc., H., 930 E. Burleigh St., Milwaukee, Wisc. (Eugene H. Schmitt)

Steljes, Martin, 105 Hill St., New Rochelle, N. Y.

Stierlen, Wilhelm, Gotenring 37, Cologne, Germany

Sullivan, C. L., Escanaba, Mich.

Taggart, A. D., Cement City, Mich.

Thompson, Warren H., 616 Stock Exchange Bldg., Buffalo, N. Y.

Trueblood, Wilford S., Monolith Portland Cement Co., 215 West 7th St., Los Angeles, Calif.

Valentine Lumber & Supply Co., 102 Albany Street, Springfield, Mass. (Frank J. Murphy)

Waterman, L. R., 1600 Peoria Life Bldg., Peoria, Ill.

Wimer, D. C., 608 Keystone Bldg., Pittsburgh, Pa.

CONVENTION REGISTRATION AT MILWAUKEE

* denotes member A. C. I.

*Abel, Norman, Allegheny County, 519 Smithfield St., Pittsburgh. Pa.

*Abrams, Duff A., International Cement Corp., 342 Madison Ave., New York City.

*Allan, W. D. M., Portland Cement Assn., 33 W. Grand Ave., Chicago Ill.

Allen, L. H., *Aberthaw Company, 80 Federal St., Boston, Mass.

Alonso, Jose M., Fuller Company, 1110 Marquette Bldg., Chicago, Ill.

*Anderegg, F. O., 206 Fulton Bldg., Pittsburgh, Pa.

Anderson, G. K., 5716 Cedar Ave., Philadelphia, Pa.

Andrew, Stephen, Concrete Products Corp., Fond du Lac, Wisc.

Angevine, R. C., Coldwater, Mich.

Armfield, H., Wisconsin Telephone Co., Fairmont Block & Maple Bldg., Wauwatosa, Wisc.

Aschbrenner, Geo., West Side Block Co., 7023 Lisbon Ave., Milwaukee, Wisc.

Asher, A. L., W. H. Pipkorn Co., 509 1st Ave., Wauwatosa, Wisc.

Aschermeyer, F. C., *Hydraulic Press Brick Co., St. Louis, Mo.

Atkinson, Geo. S., Waukesha, Wisc.

Bager, F. E., (Smith Division N. E. C.), So. Milwaukee, Wisc.
Baker, T. J., *Coddington Engineering Corp., 1012 Third St., Milwaukee, Wisc.
Ball, Chas. F., *Chain Belt Co., 4921 W. Wells St., Milwaukee, Wisc.
Banaszak, S. T., 2130 A., N. Booth St., Milwaukee, Wisc.
Bartels, Gene., 809 E. Oklahoma Ave., Milwaukee, Wisc.
Bartells, Raymond O., E. D. Coddington Mfg. Co., 780 Alexander Ave., Wauwatosa, Wisc.
Bartholomew, Tracy, *Duquesne Slag Products Co., Diamond Bank Bldg., Pittsburgh, Pa.
Bates, F. G., *Kuhlman Builders Supply & Brick Co., 2310 Scottwood Ave., Toledo, Ohio.
*Bates, P. H., Bureau of Standards, Washington, D. C.
Battenberg, D., Concrete Corp., 591 Canal St., Manitowoc, Wisc.
*Bauer, E. E., University of Illinois, 204 Mat'l Test. Lab., Urbana, Ill.
Beale, Harold W., Rockford Cement Prod. Co., Rockford, Ill.
Beleher, Wallace E., *United Engrs. & Constructors, 112 N. Broad St., Philadelphia, Pa.
Bell, F. L., Illinois Brick Co., 1983 W. Summit Ave., Milwaukee, Wisc.
Berg, C. L., *Berg Vault Co., 1620 Lucas & Hunt Rd., St. Louis, Mo.
Berry, C. U., Kalamazoo Haydite Tile Co., 1215 Howard St., Kalamazoo, Mich.
Bespalow, E. F., *Hollywood Concrete Pipe Co., 491 S. Second St., Memphis. Tenn.
*Bigler, H. P., Rail Steel Bar Assn., 228 N. LaSalle St., Chicago, Ill.
Bjarndahl, Richard, Moline Cast Stone Co., 110 18th St., Moline, Ill.
Bleck, A. T., Wisconsin Highway Comm., 744 No. 4th St., Milwaukee, Wisc.
Boden, J. P., Mil. County Highway Dept., 606 E. Otjen St., Milwaukee, Wisc.
Boelk, A. H., *Wm. H. Devos Co., 3115-29 Auer Ave., Milwaukee, Wisc.
*Bogk, Frederick C. Ricketson Mineral Color Works. 229 E. Wisconsin Ave., Milwaukee, Wisc.
Bohm, P. E., 2100 E. Ewing Ave., South Bend, Ind.
Borns, Edward, Milwaukee Gas & Lt. Co., 2907 N. 16th St., Milwaukee, Wisc.
Bowler, Jas. R., 2605 Jones St., Sioux City, Ia.
*Bowling, R. M., The Bettendorf Co., Davenport, Ia.
*Bradbury, Royall D., Wire Reinforcement Institute, 1049 Nat'l Press Bldg., Washington, D. C.
*Bradley. C. M., The Youngstown Sheet & Tube Co., E. Chicago, Ind.
*Bragger, E. Y., Medusa Portland Cement Co., Shawomet. R. I.
Brandes, Herman, 520 64th St., Wauwatosa, Wisc.
Brauns, H. F., 1917 N. 20th St., Milwaukee, Wisc.
Bremner, R. P., Petoskey Cement Co., 3051 N. Farwell St., Milwaukee, Wisc.
Brevik, Berry E., Portland Cement Assoc., 1st Wisconsin Nat'l Bank Bldg., Milwaukee, Wisc.
*Brickett, Edw. M., Lehigh Portland Cement Co., Allentown, Pa.
Brill, Alf., Milwaukee Coke & Gas Co., 2737 N. 49th St., Milwaukee, Wisc.
*Brock, A. S., The Aerocrete Western Corp., 211 Seventh W. St., Hinsdale, Ill.
Brodd, L. S., Portland Cement Assn. 425 E. Water St., Milwaukee, Wisc.
Brookman, Louis, Jr., Concrete Publishing Co., 400 W. Madison St., Chicago, Ill.
Brooks, R. E., National Equipment Corp., 2230 E. Bradford Ave., Milwaukee, Wisc.
Brown, F. E., *Smith & Brown, 307 N. Michigan Ave., Chicago, Ill.
Brown. Herbert H., 2959 N. 36th St., Milwaukee. Wisc.
*Brown, J. F., Illinois Steel Co., 208 S. LaSalle St., Chicago, Ill.
*Brown, S. N., Consumers Supply Co., 42 State St., Milwaukee, Wisc.
Browne, H. R., *Huron Portland Cement Co., Trenton, Mich.
*Browne, Nolan, Penniman Concrete & Material Co., 3000 Junius St., Dallas, Texas.
*Bruce, W. C., Barnsdall Tripoli Co., 1636 Arcade Bldg., St. Louis, Mo.
Buetow, W. C., Wisconsin Highway Comm., 333 W. Washington Ave., Madison, Wisc.
*Burggraf, Fred, Highway Research Board, Castalia, Ohio.
Burke, Jr., Martin, Milwaukee, Wisc.
Burkee, S. C., Western Lime & Cement Co., 303 E. Rosedale, Milwaukee, Wisc.
*Burks, I. E., Alcoa Power Co., Kenogami, Que., Canada.
*Burmeister, R. A., Wisc. Highway Comm., 1570 So. 15th Pl., Milwaukee, Wisc.
Burnquist, Gladys, Portland Cement Assoc., Milwaukee, Wisc.
Busalacchi, Joe, Marquette University, 3306 N. Oakland Ave., Milwaukee. Wisc.

*Butler, C. M., Marquette Cement Mfg. Co., LaSalle, Ill.
*Butler, M. R., Butler Bin Co., 154 Wisconsin Ave., Waukesha, Wisc.
Cairns, Geo. S., T. M. E. R. & L. Co., 4530 N. 28th St., Milwaukee, Wisc.
*Caldwell, J. R., *Blue Jay Concrete Prod. Co., Madison, Wisc.
Califf, E. J., *Huron Portland Cement Co., 4719 Burleigh, Milwaukee, Wisc.
Campbell, J. G., C. M. St. P. and P. R. R., 5511 Martin Dr., Milwaukee, Wisc.
*Capouch, M. E., American Steel & Wire Co., 208 So. LaSalle St., Chicago, Ill.
Carr, Harvey, Chicago, Ill.
Carter, G. S., Concrete Corporation, Milwaukee, Wisc.
Cary, Geo. E., Johns-Manville Corp. 1909 E. Kenwood Blvd., Milwaukee, Wisc.
Cavanagh, D. C., *Manitowoc Portland Cement Co., Manitowoc, Wisc.
Chadwick, Wm. J., Racine, Wisc.
*Chapman, Cloyd M., United Engrg. & Const., 105 W. 40th St., New York City.
Chapman, Webb, 2023 W. Wisc. Ave., Milwaukee, Wisc.
*Christensen, Einar, 122 E. 42nd St., New York, N. Y.
Christemann, E. B., *Julius Sorenson & Sons, 21st Northshore Ave., Racine, Wisc.
*Christoffel, John, Christoffel Art Stone Co., R. 10, Station F., Milwaukee, Wisc.
*Chubb, J. H., Pennsylvania-Dixie Cement Corp., 521 5th Ave., New York City.
*Clare, Charles, Blue Jay Concrete Products Co., 2010 Penna. Ave., Madison, Wisc.
*Clair, Miles N., Thompson-Lichtner Co., Inc., Statler Bldg., Boston, Mass.
Clarke, W. E., *American Steel & Wire Co., 208 So. LaSalle St., Milwaukee, Wisc.
*Clicquennoi, I. M., 204 Wisconsin Ave., Milwaukee, Wisc.
*Clousing, Louis, 3441 Oakland Ave., Minneapolis, Minn.
Clow, Jr., Wm. K., Waukesha Lime & Stone Co., 2041 W. Wisconsin Ave., Milwaukee, Wisc.
*Coffman, Herbert, Hercules Cement Co., 1700 Walnut St., Philadelphia, Pa.
*Colburn, D. S., Marquette Cement Mfg. Co., 140 S. Dearborn St., Chicago, Ill.
Collins, D. R., Consolidated Concrete Machy. Co., Adrian, Mich.
*Colmar, Daniel, Ramloc Stone Co., Inc., 1055 Broadway, Albany, N. Y.
*Conahey, George, Johns-Manville Corp., 292 Madison Ave., New York City.
Connell, Walter J., 341 Wisconsin Ave., Wauwatosa, Wisc.
Conrow, A. D., *Ash Grove Lime & Portland Cement Co., 204 N. Grant, Chanute, Kans.
*Crabbs, Austin, The Cements Products Co., Davenport, Ia.
Crampton, Theo. H. M., Johns-Manville Sales Corp., 3305 Frederick Ave., Milwaukee, Wisc.
Crandall, B. A., Concrete Prod. Mfg., Benton Harbor, Mich.
Cross, E. W., Cudahy Cement Block Co., 2807 Wentworth Ave., Milwaukee, Wisc.
*Crume, Wm. H., Crume Brick Co., 511 Keith Bldg., Dayton, Ohio.
*Cutler, Stanley G., Olney J. Dean & Co., 137 S. LaSalle St., Chicago, Ill.
Czarkowski, R. J., 833 E. Center St., Milwaukee, Wisc.
*Dahlquist, Geo. A., Perfected Burial Vault & Cem. Prod. Co., 2506 Irving Park Blvd., Chicago, Ill.
Dahlquist, H. A., Perfected Burial Vault & Cement Prod. Co., 2506 Irving Park Blvd., Chicago, Ill.
Dahmer, Leonard, 3615 N. 22nd St., Milwaukee, Wisc.
Dankoff, John F., Burial Vault & Concrete Block, 1214 Cleveland, E. St. Louis, Ill.
*Davis, Raymond E., University of California, Berkeley, Calif.
*Daymude, C. A., Detroit Dept. of Building & Safety Engrg., 555 Clinton St., Detroit, Mich.
Dean, John T., Milwaukee, Wisc.
DeBerard, W. W., Engineering News Record, 520 N. Michigan Ave., Chicago, Ill.
Degenhart, W. Jos., John H. Black Co., 505 Delaware Ave., Buffalo, N. Y.
*Deignan, John E., Electric Tamper & Equipment Co., 39 So. Munn Ave., East Orange, N. J.
*Deinboll, F. K., N. Y. Central Ry. Co., 1263 Brockley Ave., Lakewood, Ohio.
DeLamater, C. S., *Consolidated Concrete Machy. Corp., Adrian, Mich.
*Derleth, C. F., Colloy Production Co., 4030 Chouteau Ave., St. Louis, Mo.
*Devos, A. W., Wm. H. Devos Co., Inc., 3115-29 Auer Ave., Milwaukee, Wisc.
Devos, Wm. H., *Wm. H. Devos Co., Inc., 3115-29 Auer Ave., Milwaukee, Wisc.
DieKmann, Geo. P., Northwestern States Portland Cement Co., Mason City, Iowa.
Dienhart, E. W., *The Maul Co., 1640 E. Hancock Ave., Detroit, Mich.
Dieter, Frank L., 429 E. Milwaukee Ave., Wauwatosa, Wisc.
*Doucha, J. C., Montgomery Ward & Co., Chicago, Ill.

*Douglas, M. S., Case School of Applied Science, Cleveland, Ohio.
*Douglass, A. S., The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.
Downer, Harry E., 2737 N. Booth St., Milwaukee, Wisc.
Draeger, Edward A., 5232 36th N. St., Milwaukee, Wisc.
Draheim, Harvey A., R. 6, Box 9, Waukesha, Wisc.
Du Maire, Hans, 3355 N. Whipple St., Chicago, Ill.
Dunham, P. G., Missouri Portland Cement Co., St. Louis, Mo.
Dunphy, John J., (Marquette University), 1628 W. Wisconsin Ave., Milwaukee, Wisc.
*Eberling, C. M., 6109 Franklin Blvd., Cleveland, Ohio.
Eigel, Stanley H., 407 Commerce Bldg., Milwaukee, Wisc.
Einfeldt, A. H., 1920 12th Ave., Moline, Ill.
Elder, D. I., *Universal Atlas Cement Co., Chicago, Ill.
*Emerson, H. B., Lehigh Portland Cement Co., 111 W. Washington St., Chicago, Ill.
Engersbach, M. Engersbach Co. Inc., 962 N. 37th St., Milwaukee, Wisc.
Engelhard, A. B., Construction Material Corp., 33 No. LaSalle St., Chicago, Ill.
Engelhart, G. K., Fuller Co., 1411 Hamilton St., Allentown, Pa.
Erdman, R. B., 651 88th St., Wauwatosa, Wisc.
Evans, J. Clifford, *Nazareth Cement Co., Nazareth, Pa.
*Fairchild, L. F., Eastman Kodak Co., 3195 Lake Ave., Rochester, N. Y.
Fallon, Ray, Wisconsin Tele. Co., Hutchinson, Minn.
*Farmer, Homer G., Universal Portland Cement Co., 208 S. LaSalle St., Chicago, Ill.
Ferebee, Jas. L., 2314 E. Wyoming Place, Milwaukee, Wisc.
Ferrell, K. P., *Dewey Portland Cement Co., Davenport, Iowa.
Fickan, F. H., Miller & Blackmaur, Box 332, Mukwonago, Wis.
Findley, Marshall G., Harbor Comm., 2027 N. Prospect Ave., Milwaukee, Wisc.
Fischer, Wm. G., Reliable Block Co., 5114 Washington Blvd., Milwaukee, Wisc.
Fisher, R. J., *Masonite Corp., 4449 N. Cramer St., Milwaukee, Wisc.
Fitzgerald, Mark F., (Marquette University), 2023 W. Wisconsin Ave., Milwaukee, Wisc.,
Flatley, C. P., Flatley Bros., Co., Green Bay, Wisc.
Fleury, Antoine, 944 N. Marshall Ave., Milwaukee, Wisc.
Folbrand, C. J., *Ridge Construction Corp., 251 Elmdorf Ave., Rochester, N. Y.
*Foster, Harry L., The Foster Construction Co., 534 Coswell Bldg., Milwaukee, Wisc.
Franks, Earl R., Milwaukee, Wisc.
*Franklin, Jack, Franklin Equipment Co., 7071 Plankinton Bldg., Milwaukee, Wisc.
*Frauenfelder, Herman, Algonite Stone Mfg. Co., 4600 Chippewa St., St. Louis, Mo.
Frazier, R. W., (Marquette University), 2605 Capitol Dr., Milwaukee, Wisc.
*Freeman P. J., 519 Smithfield St., Pittsburgh, Pa.
*Friberg, B., Laclede Steel Co., St. Louis, Mo.
Fricke, Irwin, 933 Lincoln Blvd., Manitowoc, Wisc.
Fricke, Wm., 4th & Huron St., Manitowoc, Wisc.
Friede, Frederick H., 533 N. 14th St., Milwaukee, Wisc.
*Friske, A. W., 4715 State St., Milwaukee, Wisc.
Fulcher, Edmund, 404 22nd St., Brandon, Man., Canada.
Fuller, W. J., University of Wisconsin, 2562 N. 41st St., Milwaukee, Wisc.
Gamble, Raleigh W., 2563 N. Summit Ave., Milwaukee, Wisc.
*Gardiner, Lion, Lakewood Engineering Co., 520 Dublin Ave., Columbus, Ohio.
Gardner, Frank J., Gardner Laboratories, Inc., 2102 Humboldt Blvd., Chicago, Ill.
Gargen, P., 575 51st St., West Allis, Wisc.
Gates, S. J., Waller Carson & Co., 208 Mason St., Milwaukee, Wisc.
Gates, W. W., *Coddington Engineering Corp., 1012 N. 3rd St., Milwaukee, Wisc.
Gauckler, A. J., Milwaukee School Board, Milwaukee, Wisc.
Gerrits, Edward J., Wisconsin Highway Comm., Milwaukee, Wisc.
Genrich, Walter Wm., 3857 A. No. 24th St., Milwaukee Wisc.
Gertensberger, E. J., 1748 16th St., Milwaukee, Wisc.
Geise, F. A., 2667 No. 46th St., Milwaukee, Wisc.
*Ginsberg, Frank I., H. O. Penn Co., 140th St. & E. River, New York City.
Glasgow, Leon, Milwaukee, Wisc.
Gloehe, Jr., Henry, 2600 N. Main St., Racine, Wisc.
Gochmauer, B. B., Gochmauer Concrete Products Co., Appleton, Wisc.
Goes, E. J., *Koehring Company, 31st & Concordia Ave., Milwaukee, Wisc.

Golday, J. E., 840 No. Third St., Milwaukee, Wisc.

*Goldbeck, A. T., National Crushed Stone Assn., 14th & S Sts., Washington, D. C.

Goldberg, Abe., Allis Chalmers Mfg. Co., 2927 N. 55th St., Milwaukee, Wisc.

Gosswein, O. H. *Universal Atlas Cement Co., 210 So. LaSalle St., Chicago, Ill.

Gray, Alice, Chicago, Ill.

Greene, H. S., *Chain Belt Co., 736 Park St., Milwaukee, Wisc.

*Greenman, Russell S., 10 Steuben St., Albany, N. Y.

Griswold, J. C., Marquette Cement Mfg. Co., Milwaukee, Wisc.

Griweldinger, M. J., Port Washington, Wisc.

Grube, Arthur W., Sheboygan Brick Mfg. Co., Sheboygan, Wisc.

Grube, E. L., Sheboygan Brick Mfg. Co., Sheboygan. Wisc.

Gruppe, Alfred H., Bridge Dept., City of Milwaukee, 5513 W. National St., Milwaukee, Wisc.

Guenther, F. W., Guenther Cement Prod. Co., Appleton, Wisc.

Guthrie, J. N., Cincrete Corp., 2822 N. 1st St., Milwaukee, Wisc.

Hackett, Geo. M., Horniachfeger Corp., Eau Claire, Wisc.

*Haegert, Lee V., 2240 W. 8th St., Topeka, Kans.

*Hagener, Arthur, Whitacre Engineering Co., 228 N. LaSalle, Chicago, Ill.

*Hahn, Harold S., Milwaukee Testing Lab., 2018 E. Greenwich Ave., Milwaukee, Wisc.

Haight, E. E., *Concrete Publishing Co., 400 W. Madison St., Chicago, Ill.

Hall, Bodine, Highway Comm., Milwaukee, Wisc.

Hambrecht, A. L., Wisconsin Highway Comm., 2248 Rowley Ave., Madison, Wisc.

*Hammerschmidt, Martin, Elmhurst-Chicago Stone Co., 400 W. 1st St., Elmhurst, Ill.

*Hanna, W. C., California Portland Cement Co., Colton, Calif.

*Hanneman, R. F., Hanneman Bros., 7841 South St., Detroit, Mich.

Hansen, R. M., Manitowoc Portland Cement Co., Milwaukee, Wisc.

Hanson, E. S., "Concrete Products," 542 S. Dearborn St., Chicago, Ill.

Harris, E. F., Wilson Construction Co., 107 W. College Ave., Appleton. Wisc.

*Harris, Wallace R., Cincrete Corp., Hotel Plaza, Milwaukee, Wisc.

Hart, Walter L., 696 58th St., Milwaukee, Wisc.

Hatton, T. Chalkley, Milwaukee, Wisc.

Hautkamp, H. R., T. M. E. R. & L. Co., 501 2nd Ave., Wauwatosa, Wisc.

Heller, Walter, Economy Block Co., 1407 N. Franklin, Apt. 6, Milwaukee, Wisc.

Helphinstine, S. P., *W. G. Traver Supply Co., 1902 N. Water St., Decatur, Ill.

*Hedderich, H. F., Westinghouse Elec. & Mfg. Co., 3850 Bingham Ave., St. Louis, Mo.

Heine, F. H., T. L. Smith Co., Milwaukee, Wisc.

Herwig, W. G., Economy Concrete Prod. Co., 3206 W. Madison, Milwaukee, Wisc.

Hibbard, F. G., Milwaukee El. Ry. & Lt. Co., 423 Public Service Bldg., Milwaukee, Wisc.

Hickey, J. Francis, T. M. E. R. & L. Co., 917 N. 26th St., Milwaukee, Wisc.

Higgins, Jack, 829 81st Ave., West Allis, Wisc.

Hill, G. E., Wisconsin Highway Comm., Green Bay, Wisc.

Hinkamp, Grant M., G. R. Fehr, Inc., 2966 N. 49th St., Milwaukee, Wisc.

*Hirth, G. W., Hirth Concrete Breaking Co., 727 W. Chambers St., Milwaukee. Wisc.

*Hirschberg, Walter P., Federal Engr. Co., 218 Stephenson Bldg., Milwaukee, Wisc.

*Hoerr, P. J., 1104 Fry Ave., Peoria, Ill.

Hoffman, L. A., Milwaukee Co. High. Dept., 1738 N. 33rd St., Milwaukee, Wisc.

Holland, H. D., Cooksville Co., Cooksville, Ont., Canada.

Holler, Jr., Wm. C., 891 60th St., Wauwatosa, Wisc.

Hollingshied, T. H., Zion Institute and Industries, Zion, Ill.

*Hollister, S. C., Purdue University, Lafayette, Ind.

Holmberg, Jos. C., 1018 South 29th St., Milwaukee, Wisc.

Holmes. Martin, 1723 E. Beverly Road, Milwaukee, Wisc.

Holsinger, E. E., Lake Ports Supply Co., Sturgeon Bay, Wisc.

Holzman, M., Best Block Co., 1157 50th St., Milwaukee, Wisc.

*Hooks, James H., Alberene Stone Co., 153 W. 23 St., New York City.

Hoppe. B. C., Cincrete Corp., 724 12th Ave., Wauwatosa, Wisc.

Hopwood, Robert Lawrenceburg, Tenn.

Horn, Lawrence, Marquette University, 2859 W. Murray Ave., Milwaukee, Wisc.

Hoskin, A. J., Pit and Quarry, Chicago, Ill.

Howard, E. A., Milwaukee, Wisc.

Hoya, Roy M., The T. L. Smith Co., 2814 N. 37th St., Milwaukee. Wisc.

*Hubbard, Fred, 133 Halleek St., Youngstown, Ohio.

Hug, Fred, 725 37th St., Milwaukee, Wisc.
Hughes, A. Walter, 34 Court St., City of Rochester, N. Y.
*Hughes, C. A., University of Minnesota, Minneapolis, Minn.
Huiras, Frank, Wisconsin Highway Comm., 1229 N. 34th St., Milwaukee, Wisc.
*Hutchinson, G. W., Riverton Lime Co., Riverton, Va.
*Hutter Geo. F., Hutter Construction Co., 128 Western Ave., Fond du Lac., Wisc.
Jackson, C., Chicago, Ill.
*Jackson, F. H., U. S. Bureau of Public Roads, Washington, D. C.
Jackson, F. N., Saunders Construction Co., Big Bend, Wisc.
Jaeckle, Clarence H., Okanchee, Wisc.
Jackle, Julius, Okanchee, Wisc.
James, E. W., 6746 Maple Terrace, Wauwatosa, Wisc.
Jansen, J. G., Concrete Products Co., Milwaukee, Wisc.
*Jennings, D. F., American Concrete Institute, Detroit, Mich.
*Jennings, Wm. A., So. Portland Cement Co., Box 322, Osborn, Ohio.
Jensen, A. C., 1809 Thurston Ave., Racine, Wisc.
Jensen, C. F., 1725 Wisconsin Ave., Milwaukee, Wisc.
Johanning, P. M., 3016 So. Superior St., Milwaukee, Wisc.
*Johnson, A. V., Ideal Cement Stone Co., Omaha, Nebr.
Johnson, Ben, Oshkosh, Wisc.
Johnson, Chris, Oshkosh, Wisc.
*Johnson, C. S., The C. S. Johnson Co., 1002 N. Market St., Champaign, Ill.
Johnson, Marvin O., Wisconsin Highway Comm., 654 Mabbett Ave., Milwaukee, Wisc.
Johnson, Ralph F., Highway Comm., 605 N. 13th St., Milwaukee, Wisc.
*Johnson, Robert C., Immel Construction Co., 19 W. Division St., Fond du Lac, Wisc.
*Johnson, R. W., Concrete Reinforcing Steel Institute, 1207 Tribune Tower, Chicago, Ill.
Johnson, Stanley, *Concrete Publishing Co., 1617 Ridge Ave., Evanston, Ill.
Jones, H. B., National Equipment Co., 525 Barry Ave., Chicago, Ill.
Jones, W. E., Cook & Brown, Oshkosh, Wisc.
Jumper, C. H., Bureau of Standards, Washington, D. C.
*Kahler, G. A., Prairie Concrete Products Co., Prairie Du Chien, Wisc.
Kahn, Wm. A., 2148 N. 46th St., Milwaukee, Wisc.
Kaiser, Frank A., Engr. Board of Harbor Comm., Milwaukee, Wisc.
*Kalinka, J. E., Roberts Schaefer Co., Wrigley Bldg., Chicago, Ill.
Keihl, H., 3911 24th St., Milwaukee, Wisc.
*Kennedy, John W., Huron Portland Cement Co., Ford Bldg., Detroit, Mich.
Kepplinger, W. C., 1150 Wisconsin Ave., Beloit, Wisc.
Kern, James, 1911 E. Newton Ave, Milwaukee, Wisc.
Kerler, E. A., *E. D. Coddington Mfg. Co., Milwaukee, Wisc.
Kessler, Jr., O. H., Hackendahl Schmidt Co., 2478 N. 45th St., Milwaukee, Wisc.
Kilmer, Harve, Iowa Concrete Crib & Silo Co., Des Moines, Iowa.
King, Ben, City Hall, Watertown, Wisc.
Kirchen, Adolph W., 2571 N. 39th St., Milwaukee, Wisc.
Klein, U. W., 3476 N. West St., Milwaukee, Wisc.
Kline, Chas., Pitts Testing Lab., 2224 N. Prospect Ave., Milwaukee, Wisc.
Kline, J. F., Pitts Testing Lab., 2224 N. Prospect Ave., Milwaukee, Wisc.
Klug, A. L., Johns-Manville Corp., Milwaukee, Wisc.
Knapp, Lloyd D., City Engrs. Office, 2818 N. 54th St., Milwaukee, Wisc.
Koch, Al. J., 5332 N. Holton St., Milwaukee, Wisc.
Koehring, Robert C., *Koehring Co., 31st & Concordia Ave., Milwaukee, Wisc.
*Koepke, G. A., 201 E. College Ave., Appleton, Wisc.
*Kolinski, M. C., Kolinski Ready Mixed Concrete Co., 127 S. 11th St., West Allis, Wisc.
Kramer, E. G., Barnsdall Tripoli Co., 1657 Meade Ave., Chicago, Ill.
Kramsky, Meyer, Wisconsin Highway Comm., Milwaukee, Wisc.
Krenz, Leo, (Marquette University), 2023 W. Wisconsin Ave., Milwaukee, Wisc.
Krinkel, Aug. E., 2959 N. 50th St., Milwaukee, Wisc.
Kuelling, H. J., Madison, Wisc.
Kuhlman, E. H., *Kuhlman Builders Supply & Brick Co., Toledo, Ohio.
Ladwig, Alf. A., 2947 7th N. St., Milwaukee, Wisc.
Ladwig, Jr., Otto, Otto Ladwig & Sons, Inc., 4541 Green Bay Ave., Milwaukee, Wisc.
Ladwig, Walter, Otto Ladwig & Sons Inc., 3742 No. 7th St., Milwaukee, Wisc.
Landsiedel, Wm., 3073 So. Shore Drive, Milwaukee, Wisc.

Lange, Arnold E., 2913 N. 35th St., Milwaukee, Wisc.
Lange, W. H., 917 4th St., West De Pere, Wisc.
Langley, Jr., Geo., County Highway Engr., Sheboygan, Wisc.
*Larkin, Chas. W., Carnegie Institute of Technology, Pittsburgh, Pa.
*Larson, Guy H., Wisconsin Highway Comm., Madison, Wisc.
*Larson, L. J., A. O. Smith Corp., 3306 N. Shepard Ave., Milwaukee, Wisc.
Last, Clarence A., 2862 N. 57th St., Milwaukee, Wisc.
Lawrence, G. L., Cunningham Ort Mayer Co., Milwaukee, Wisc.
Lee, Lester, 2942 N. 2nd St., Milwaukee, Wisc.
Leftwich, R. F., *Raymond Concrete Pile Co., 140 Cedar St., New York City.
*Lehner, Walter J., Mt. Clemens, Mich.
Lembcke, L. W., Universal Construction Co., 3252 51st Blvd., Milwaukee, Wisc.
*Lenhardt, L. G., Detroit Water Board, 2688 Lawrence Ave., Detroit, Mich.
Levin, Eugene A., 1529 N. 48th St., Milwaukee, Wisc.
*Levison, Arthur A., Blaw-Knox Co., Pittsburgh, Pa.
Lewis, J. E., *American Concrete Marbelite Co., 4727 N. Lamon Ave., Chicago, Ill.
Libbey, V. B., *Hawaiian Contracting Co. Ltd., 854 Kaahumanu St., Honolulu, T. H.
*Lichtenberg, E., Koehring Co., 31st St. & Concordia Ave., Milwaukee, Wisc.
*Lindau, A. E., American System of Reinforcing, Union Trust Bldg., Chicago, Ill.
*Lindsay, G. L., Universal Atlas Cement Co., 208 S. LaSalle St., Chicago, Ill.
Lippert, J. R., Homes Const. Co., 3921 Maryland Ave., Milwaukee, Wisc.
*Lord, Arthur R., Lord & Holinger, Inc., 140 S. Dearborn St., Chicago, Ill.
*Loucks, H. F., Lehigh Cement Co., 111 W. Washington St., Chicago, Ill.
*Love, H. J., National Slag Assoc., Cleveland, Ohio.
*Lowell, J. W., Benedict Stone Co., 7402 S. Ashland Ave, Chicago, Ill.
*Lynch, C. A., Foote Co., Inc., Nunda, N. Y.
*Lyse, Inge, Lehigh University, Bethlehem, Pa.
McAnally, Chas. G., Gifford-Wood Co., Aurora, Ill.
*McCarty, M. J., Electric Tamper & Equipment Co., 433 Railway Exchange Bldg., Chicago, Ill.
McClurg, Verne O. *Holabird & Root, 333 N. Michigan Ave., Chicago Ill.
*McCullough, F. M., Carnegie Institute of Technology, Pittsburgh, Pa.
McEvoy, E. J., City Engineers Office, Milwaukee, Wisc.
McGuire, John R., Wisconsin Highway Comm., 719 N. 21st St., Milwaukee. Wisc.
*McIntyre, Geo. E., 1009 Baltimore Ave., Kansas City, Mo.
McKenzie Donald A., Cincrete Corp., Milwaukee, Wisc.
McKibbin, T. A., Wisconsin Highway Comm., Milwaukee, Wisc.
McKillop, David, Detroit Edison Co., Detroit, Mich.
McLafferty, J. E., Hall Steel Joist Co., 2606 N. Palmer St., Milwaukee. Wisc.
*McMillan. F. R., Portland Cement Assn., 33 W. Grand Ave., Chicago, Ill.
McQuestion, H. J., North Shore Cement Vault Co., Kenosha, Wisc.
McQuestion, W., North Shore Cement, Vault Co., 6046 34th Ave., Kenosha, Wisc.
McQuestion, W. P., North Short Cement Vault Co., 2721 73rd St., Kenosha, Wisc.
Madsen, Andrew L., Itasca, Ill.
McFalls, E. L., *Master Builders Co., 7016 Euclid Ave., Cleveland, Ohio.
Maiers, Jas. A., 2555 N. 45th St., Milwaukee, Wisc.
Mell, E. Q., Mo. State Highway, 3539 Gillham St., Kansas City, Mo.
*Maney, G. A., Northwestern University, 2732 Laundale, Evanston, Ill.
Mangold, Fred, Whitehall, Mich.
Manhardt, Chester E., 275 E. North Ave., Wauwatosa, Wisc.
Manhardt, W. J., Best Block Co., 3522 N. Fratney St., Milwaukee, Wisc.
Marquardt, Wm., Quality Block Co., 3237 N. 14th St., Milwaukee, Wisc.
Markle S. H., Markle Cement & Coal Co., Muskegon, Mich.
*Mason, Roscoe J., 3221 Lenox Ave., Detroit, Mich.
Marshall, R. 6553 Woodward Ave., Detroit, Mich.
Marx, Charles H., Sewerage Comm., 2912 W. Walls St., Milwaukee, Wisc.
Mathias, H. C., Toledo Scale Co., Toledo, Ohio.
*Mavis, F. T., University of Iowa, Iowa City, Iowa.
Mayer, C. H., Schmidt, Garden & Erikson, 104 S. Michigan Ave., Chicago, Ill.
Meier, H. E., N. W. Doe Cement Block Co., Davenport, Iowa.
Meier, J. E., Wisconsin Highway Comm., 515 Brasted Pl., Waukesha, Wisc.
Meier, Wm. J., Lansing, Mich.
Meurer, John, 401 N. 50th St., Milwaukee, Wisc.

*Meyer, M. W., Anti-Hydro Waterproofing Co., 295 Badger Ave., Newark, N. J.
Meyer, Walter G., W. H. Pipkorn Co., 1548 West Bruce St., Milwaukee, Wisc.
Mihills, D. R., National Food Co., Fond du Lac, Wisc.
Mitchell, Frank, Kolinski Ready Mixed Concrete Co., 3457 S. New York, Milwaukee, Wisc.
Mitchell, John J., Ash Grove Lime & Portland Cement Co., 5136 Agatete, Chicago, Ill.
*Moore, O. L., Universal Atlas Cement Co., 210 So. LaSalle St., Chicago, Ill.
Morgan, R. W., Larsen-Morgan Co., Oshkosh, Wisc.
Moritz, F. G., Wolverine Portland Cement Co., Milwaukee, Wisc.
*Morrill, Arthur B., Detroit Dept. of Water Supply, 8100 W. Warren Ave., Dearborn, Mich.
Morris, Mason H., Highway Comm., Milwaukee, Wisc.
Morse, O. F., Morse Cement Tile Co., North East, Pa.
Mortag, Ed. H., *T. L. Smith Co., 2655 N. 38th St., Milwaukee. Wisc.
Morton, A. R., *Butler Bin Co., 154 Wisconsin Ave., Waukesha, Wisc.
Moul, Alenn, Economy Concrete Products Co., Milwaukee, Wisc.
Muehrcke, B. C., Milwaukee Co. Highway Dept., 964 N. 27th St., Milwaukee, Wisc.
Mueller, A. J., Wolverine Portland Cement Co., Milwaukee, Wisc.
Mulhaney, Arthur, Economy Concrete Products Co., Waukesha, Wisc.
Myron, J. A., *Cincinnati Union Terminal Co., 1020 Temple Bar Bldg., Cincinnati, Ohio.
Nash, Wm. E., Turner Construction Co., 701 N. Michigan, Chicago, Ill.
Neatwait, G., *Republic Fireproofing Co., 31 Union Sq., New York City.
Nelson, Clifford, 5303 Mitchel St., West Allis, Wisc.
Nelson, C. M., Gillette Publishing Co., Chicago, Ill.
Nelson, O. T., Industrial Comm., Madison, Wisc.
Newbauer, Wm. H., T. M. E. R. & L. Co., 2135 No. 10th St., Milwaukee, Wisc.
Newhouse, R. C., Allis Chalmers Mfg. Co., 309 7th Ave., Wauwatosa, Wisc.
Newman, A. O., Alamo Concrete Pipe Co., Antonio, Texas.
Noble, T. W., Consolidated Con. Machy. Corp., Tribune Tower, Chicago, Ill.
Noren, Walter. Zion Institute & Industries, Zion, Ill.
Oberdank, John, State Highway Comm., 3125 Wells St., Milwaukee, Wisc.
Oestreich, Carl R., 2138 S. Layton Blvd., Milwaukee, Wisc.
Olisaewski, Casimir, (Marquette University), 1815 W. Mitchell St., Milwaukee, Wisc.
Olroge, C. H., Medusa Cement Co., Milwaukee, Wisc.
*Olsen, E., Badger Concrete Co., 191 Marion St., Oshkosh, Wisc.
*Olsen, E. F., Consolidated Concrete Machinery Co., Adrian, Mich.
Olson, O. N., (Marquette University), 561 N. 14th St., Milwaukee, Wisc.
O'Reilly, Lawrence, *S. M. Siesel Co., 2023 W. Wisconsin Ave., Milwaukee, Wisc.
Ostermeier, Alvin A., 2530 N. Grant Blvd., Wauwatosa, Wisc.
Pacholski, E. M., Wisconsin University, 5515 N. Danburg Rd., Whitefish Bay, Wisc.
*Painter, Geo. M., Belmont Cement Burial Case Co., W. Manayunk, Pa.
Patitz, W. E., Wisconsin Highway Comm., 732 N. 17th St., Milwaukee, Wisc.
*Patzig, Monroe L., Patzig Laboratories, Des Moines, Iowa.
Paul, Frederick, 203 City Hall, Minneapolis, Minn.
*Pearson, J. C., Lehigh Portland Cement Co., Young Bldg., Allentown, Pa.
*Pease, B. S., American Steel & Wire Co., 208 S. LaSalle St., Chicago, Ill.
Peck, Roy L., Pittsburgh Testing Laboratory, 205 W. Wacker Drive, Chicago, Ill.
Peirce, W. A., Racine, Wisc.
Peterson, Kenneth, (Marquette University), 3172 N. 34th St., Milwaukee, Wisc.
*Peterson, Lawrence E., Osthoff-Peterson Co., Inc., 312 E. Wisconsin Ave., Milwaukee, Wisc.
*Pettus, L. A., Hydraulic Press Brick Co., 705 OliveSt., Room 1000, St. Louis. Mo.
*Pittner, L. E., Cincrete Products Corp., 591 Canal St., Milwaukee, Wisc.
Plautz, E. G., Wisconsin Highway Comm., Granville, Wisc.
*Pletta, Dan H., University of South Dakota, Vermillion, S. D.
Poenichen, W. E., Zanesville Sand & Gravel Co., 2911 S. Superior St., Milwaukee, Wisc.
Polansky, Theo. A., Union Concrete Pipe Co., Huntington, W. Va.
Pollock, G. W., *National Equipment Corp., 2849 N. Prospect St., Milwaukee, Wisc.
Poppy, C. C., City Engr. Dept., Milwaukee, Wisc.
Porath. A. A., Brown Co., Highway Comm., Green Bay, Wisc.

Porter, G. W., *Universal Atlas Cement Co., 210 So. LaSalle St., Chicago, Ill.
Potts, H. H., H. H. Potts Co., 201 North Wells St., Chicago, Ill.
Poulter, John, *National Equipment Corp., Milwaukee, Wisc.
Powers, Sanger B., 2212 N. 39th St., Milwaukee, Wisc.
*Powers, T. C., Portland Cement Assoc., 33 W. Grand Ave., Chicago, Ill.
*Price, Philip W., 519 Smithfield St., Pittsburgh, Pa.
*Proudley, C. E., National Sand & Gravel Assoc., 545 Munsey Bldg., Washington, D. C.
*Putnam, Wm. J., University of Illinois, Urbana, Ill.
Quimby, Frank K., 934 Hayes Ave., Racine, Wisc.
Ramm, C. H., *E. L. Ramm Co., LaGrange, Ill.
*Ramm, Ed. L., E. L. Ramm Co., LaGrange, Ill.
*Randall, Frank A., 205 W. Wacker Drive, Chicago, Ill.
Reichert, E. J., Wisconsin Highway Comm. Civ. No. 2, Milwaukee, Wisc.
Reichardt, W. F., Watertown, Wisc.
Reinhart, Milton W., Wisconsin Highway Comm., Milwaukee, Wisc.
Reick, C. F., *Consumers Supply Co., 42nd & State Sts., Milwaukee, Wisc.
*Richart, F. E., University of Illinois, Urbana, Ill.
Rick, C., 2364 S. 13th St., Milwaukee, Wisc.
Rich. T. T., A. O. Smith Corp., 2364 S. 13th St., Milwaukee, Wisc.
Roberts, Emory D., Marquette, University, Milwaukee, Wisc.
Roedl, L. F., Metro. Sewerage Comm., 2023 W. Wisconsin Ave., Milwaukee, Wisc.
Robinson, H. M., *Underwriters Laboratories, 207 E. Ohio St., Chicago, Ill.
Robinson, Ray, Wisconsin Highway Comm., Milwaukee, Wisc.
Rockwood, E. F., *Deslauriers Column Mould Co., Inc., 101 Tremont St., Boston, Mass.
*Rockwood, Nathan C., Rock Products, 542 S. Dearborn St., Chicago, Ill.
Roder, J. M., Milwaukee, Wisc.
Rohde, Hugo Wm., Milwaukee Engineering Society, 3927 N. Stowell Ave., Milwaukee, Wisc.
Rollman, O. C., Green Bay, Wisc.
Romaine, Henry F., 1417 Railway Exchange, Chicago, Ill.
Ruhl, Wm. A., *Chain Belt Co., Milwaukee, Wisc.
*Rush, D. B., Robt. W. Hunt & Co., 2200 Insurance Exchange, Chicago, Ill.
Rybeck, A. W., *T. L. Smith Co., Milwaukee, Wisc.
*Saeger, Geoff. A., Missouri Portland Cement Co., 1010 Pine St., St. Louis, Mo.
Sarnow, Ray E., 5407 McKinley Ave., Milwaukee, Wisc.
Scheer, A. W., Best Block Co., 2357 N. 2nd St., Milwaukee, Wisc.
Scherer, P. W., Western Lime & Cement Co. Milwaukee, Wisc.
Schroeder, Frank C., T. M. E., R. & L. Co., 709 E. Jemaon Ave., Milwaukee, Wisc.
Schmidt, Eugene A., 2024 N. 56th St., Milwaukee, Wisc.
Schmidt, Paul E., 3291 N. 8th St., Milwaukee, Wisc.
Schmitt, F. E., Engineering News-Record, New York City.
Schneider, Wm., Concrete Products Co., 2802 Center St., Milwaukee, Wisc.
Schnoebelen, F. W., 4803 W. State St., Milwaukee, Wisc.
Schoepke, Donald, 533 N. 14th St., Milwaukee, Wisc.
Schroeder, A. C., Economy Concrete Product Co., 1823 Cherry St., Milwaukee, Wisc.
Schuh, A. R., Waukesha, Wisc.
Schumacher, Robert E., 1250 N. 46th St., Milwaukee, Wisc.
Schunck, Willard L., 4706 Beloit Rd., Milwaukee, Wisc.
Schwada, J. P., 923 49th St., Milwaukee, Wisc.
Schwalbe, L. E., Economy Concrete Product Co., Wauwatosa, Wisc.
Schwinn, Otto. Better Block Co., Inc., 3338 N. 42nd St., Milwaukee, Wisc.
*Scripture, Jr., E. W., Master Builders Co., 7016 Euclid Ave., Cleveland, Ohio.
Sehier, Victor J., 2632 W. Walnut St., Milwaukee, Wisc.
Seifert, Andrew, U. S. Bureau of Public Roads, St. Paul, Minn.
Sengenberger, John G., *Ideal Concrete Co., Inc., Joliet, Ill.
Shafer, Jr., Sam, *Chain Belt Co., 736 Park St., Milwaukee, Wisc.
*Shank, J. R., Ohio State University, Columbus, Ohio.
Sheafer, Theodore E., Cleveland, Ohio.
Sheahen, Ed., West Allis, Wisc.
Sheck, Oscar, *Koehring Co., Milwaukee, Wisc.
Shields, Harry C., Marquette Cement Mfg. Co., Chicago, Ill.
Shiely, Albert R., J. L. Shiely Co., St. Paul. Minn.

Shilbauer, R., *Chain Belt Co., 736 Park St., Milwaukee, Wisc.
*Shuman, E. C., Portland Cement Assoc., 33 W. Grand Ave., Chicago, Ill.
Siegert, B. F., Lime Product Co., Wauwatosa, Wisc.
Siegert, Wm. P., Economy Concrete Prod. Co., 360 State St., Wauwatosa, Wisc.
*Siesel, S. M., S. M. Siesel Co., 514 Ogden Ave., Milwaukee, Wisc.
*Simmond, Fred C., 927 S. 29th St., Milwaukee, Wisc.
Slack, R. E., Federal American Cement Tile Co., 14516 Clark St., Riverdale, Ill.
Slye, Merle E., 1439 W. Chambers St., Milwaukee, Wisc.
Slater, Thomas M., Wisconsin Telephone Co., Milwaukee, Wisc.
*Slater, W. A., Lehigh University, Bethlehem, Pa.
Sloane, F. M., C. M. St. P. & P. R. R. Co., Milwaukee, Wisc.
Smet, A. G., Fond du Lac, Wisc.
*Smith, Albert, Smith & Brown, 307 N. Michigan Ave., Chicago, Ill.
Smith, C. U., Milwaukee Harbor Comm., Milwaukee, Wisc.
Sorenson, Arthur J., *Julius Sorenson & Sons, 21st & Northshore Tracks, Racine, Wisc.
Sorenson, Harry N., *Julius Sorenson & Sons, 21st & Northshore Tracks. Racine, Wisc.
*Spaight, H. L., Cinder Block & Material Co., Cedar Rapids, Iowa.
Steck, E., Johns-Manville Corp., Milwaukee, Wisc.
Stetson, Roger H., Iowa Concrete Crib & Silo Co., Des Moines, Iowa.
Stetter, F. E., 1016 N. 49th St., Milwaukee, Wisc.
Stevenson, Wm. A., Wisconsin University, Milwaukee, Wisc.
*Stewart, L. C., The Dow Chemical Co., Midland, Mich.
*Stineman, Norman, Concrete Publishing Co., 400 W. Madison Ave., Chicago, Ill.
Stokes, C. R., Wisconsin Highway Comm., Madison, Wisc.
Strawbridge, E. T., *Western Brick Co., Danville, Ill.
Stransky, Joseph A., Wisconsin Highway Comm., Milwaukee, Wisc.
Strothman, E. A., Milwaukee County Highway Comm., Milwaukee, Wisc.
Stuewe, W. F., Badger Sand & Gravel Co., Milwaukee, Wisc.
*Sullivan, P. L., Universal Cinder Prod. Co., Escanaba, Mich.
Sullivan Ralph C. Concrete Products, Chicago, Ill.
Sutherland, S. J., Milwaukee School Board, Milwaukee, Wisc.
*Swanson, C. E., K. C. Duntile Co., 4531 Summit, Kansas City, Mo.
*Taege, Paul C., Arlington Concrete Products Co., Arlington Heights, Ill.
*Taggart A. D., W. E. Dunn Mfg. Co., Cement city, Mich.
*Talbot, A. N., University of Illinois, Urbana, Ill.
*Talbot, Kenneth H., National Equipment Corp., 30th & Concordia Ave., Milwaukee, Wisc.
Tanghe, E. L., 2356 N. 54th St., Milwaukee, Wisc.
*Tatnall, F. G., Baldwin-Southwark Corp., Philadelphia, Pa.
Taylor, S. L., U. S. Bureau of Public Rds., St. Paul, Minn.
Ter Maath, B. C., 309 Elliott St., Janesville Wisc.
Teter Donald S., 2942 N. 2nd St., Milwaukee, Wisc.
Tews, Walter, Milwaukee, Wisc.
Thaon, L. C., Pit and Quarry, Wheaton, Ill.
*Thee, T. C., 864 Saunders Kennedy Bldg., Omaha, Nebr.
*Thomson, H. F., General Material Co., 605 Buder Bldg., St. Louis, Mo.
Thompson, Paul, *General Material Co., 605 Buder Bldg., St. Louis, Mo.
*Thompson, Sanford E., Thompson-Lichtner Co., Boston, Mass.
*Thompson, W. S., Kalman Steel Co., Wrigley Bldg., Chicago, Ill.
Torkelson, F. A., 525 7th Ave., Wauwatosa, Wisc.
Tracy, C. Curtis, American Institute of Steel Const., Milwaukee, Wisc.
Tranass, Emil, *Koehring Co., Milwaukee, Wisc.
*Traver, W. G., 1902 N. Water St., Decatur, Ill.
Troller, G. F., Milwaukee. Wisc.
Tubesing, Rudolph G., 789 4th Ave., Wauwatosa, Wisc.
*Tubesing, Wm. F., 2904 N. Oakland Ave., Milwaukee, Wisc.
Ubbink, W. J., Port Washington, Wisc.
Uehling, Ed. A., Milwaukee, Wisc.
Ullius, F. W., 3445 N. Cramer St., Milwaukee, Wisc.
*Urquhart, L. C., Cornell University, Ithaca, N. Y.
*Van Houten, Chas., 4536 Wentworth Ave., Chicago, Ill.

*Van Scoyoc, H. S., Canada Cement Co., Ltd., 205 Brock Ave., N. Montreal, Canada.
Vasholz, Amo, Diamond Cartage, 2715 W. 24th St., Milwaukee, Wisc.
Versluis, Paul M., 1510 17th St., East Moline, Ill.
Wagner, H. A., 8 So. Michigan Ave., Chicago, Ill.
Wagner, K. E., *Whitacre Engineering Co., Chicago, Ill.
Wagner, R. J., *Chain Belt Co., Milwaukee, Wisc.
Wahler, E. J., Badger Sand & Gravel Co., Milwaukee, Wisc.
Waite, Jack, Waukesha Cement Tile Co., Waukesha, Wisc.
Walish, Gene, 2811 N. 34 St., Milwaukee, Wisc.
*Walker, C. G., Portland Cement Assn., 33 W. Grand Ave., Chicago, Ill.
*Walker, Stanton, National Sand & Gravel Assn., Washington, D. C.
Walsh, J. A., Concrete Products, 539 S. Dearborn St., Chicago, Ill.
*Walter, L. W., Erie Railroad Co., 168 Provost St., Jersey City, N. J.
Wanta, Wm., 4474 N. Morris Blvd., Milwaukee, Wisc.
*Weatherbee, L. B., Cooksville Co., 26 Queen St. E., Toronto, Ont., Canada.
Weber, Edward H., 2954 Frederick Ave., Milwaukee, Wisc.
*Weber, Lester N., The Sisalkraft Co., 205 W. Wacker Drive, Chicago, Ill.
*Weigel, Fred, Southern Cement Products Co., Knoxville, Tenn.
Weimer, Hugo W., 744 N. 4th St., Milwaukee, Wisc.
Weldon, John T., 2522 N. Palmer St., Milwaukee, Wisc.
Wells, Edw. W., Moline Cast Stone Co., Moline, Ill.
Welton, L. Lloyd, 612 W. Clarke St., Milwaukee, Wisc.
Westerveld, I. J., *Wausau Concrete Co., Wausau, Wisc.
Westlund, Morton S., Elec. Tamper & Equip. Co., 4880 Kenmore Ave., Chicago, Ill.
Weymouth, C. R., 3627 N. Humboldt Ave., Milwaukee, Wisc.
*Wheeler, W. H., Washington University, St. Louis, Mo.
Whipperman, Frank, Besser Mfg. Co., Omaha, Nebr.
*Whitney, Chas. S., 724 S. Mason St., Milwaukee, Wisc.
*Whipple, Harvey, American Concrete Institute, Detroit, Mich.
*Wiepking, C. A., 608 52nd St., Milwaukee, Wisc.
Wiley, G. E., School Board, Milwaukee, Wisc.
*Wilk, Benjamin, Standard Building Products Co., 14250 Cloverdale St., Detroit, Mich.
Will, W. J., Wauwatosa Fuel & Supply Co., Wauwatosa, Wisc.
Willson, C. A., State Architects Office, Madison, Wisc.
*Wilsnack, G. C., Edison Cement Corp., 242 N. 10th St., Easton, Pa.
Wilson, C. E., Alpha Portland Cement Co., Chicago, Ill.
*Wilson, Ethel B., American Concrete Institute, Detroit, Mich.
Wilson, James J., Harrison Hotel, Chicago, Ill.
Wing, Frank G., Milwaukee Power Equipment Co., Milwaukee, Wisc.
*Withey, M. O., University of Wisconsin, Madison, Wisc.
*Withrow, R. E., Medusa Portland Cement Co., 1200 Webb Road, Lakewood, Ohio.
*Witt, J. C., Universal Atlas Cement Co., 5834 Stony Island Ave., Chicago, Ill.
Woldl, Norman, *Cincrete Corp., Milwaukee, Wisc.
Woodworth, P. M., Portland Cement Assn., 256 Van Danish St., Glen Ellyn, Ill.
Yahr, Leonard J., West Bend Concrete Prod. Co., West Bend, Wisc.
*Yandell, C. H., Yandell & Conger, Jackson, Tenn.
Yeoman, R. C., Construction Materials Corp., Chicago, Ill.
*Young, C. R., University of Toronto, Toronto, Canada.
Young, Howard L., Lith-I-Bar Co., Kalamazoo, Mich.
*Young, W. J., Edw. E. Dreisbach, Martinsburg, W. Va.
*Younglove, C. C., W. A. Klinger, Inc., Warnock Bldg., Sioux City, Iowa.
*Zabriskie, Wm. F., Gabriel Steel Co., 13700 Sherwood Ave., Detroit, Mich.
Zaichek, Geo., 3613 N. 22nd St., Milwaukee, Wisc.
Zander, Karl L., 5518 6th Ave., Kenosha, Wisc.
*Zass, W. W., State Highway Comm., Little Rock, Ark.
Zofky, C. L., Wisconsin Machine Works, 1112 South 6th St., Milwaukee, Wisc.

LADIES

Bowling, Mrs. R. M., Davenport, Iowa.
Brevik, Mrs. B. E., 658 9th Ave., Wauwatosa, Wisc.
Brodd, Mrs. L. S., Milwaukee, Wisc.

Clair, Mrs. Miles N., 17 Hope St., West Newton, Mass.

Clicquennoi, Mrs. I. M., 204 Wisconsin Ave., Milwaukee, Wisc.

Druecker, Mrs. H. T., 3956 N. Murray Ave., Milwaukee, Wisc.

Franklin, Mrs. J., 2427 Wisconsin Ave., Milwaukee, Wisc.

Fulcher, Mrs. Edmund, 404 22nd St., Manitoba, Canada.

Greene, Mrs. H. S., Milwaukee, Wisc.

Newhouse, Mrs. R. C., 309 7th Ave., Wauwatosa, Wisc.

Roberts, Mrs. Emory D., 2435 W. Wisconsin Ave., Milwaukee, Wisc.

Rohde, Mrs. H. W., 3927 N. Stowell Ave., Milwaukee, Wisc.

Schmitt, Mrs. H. A., 2107 E. Beverly Rd., Milwaukee, Wisc.

Schwada, Mrs. Joseph P., 2503 W. 49th St., Milwaukee, Wisc.

Sloane, Mrs. F. M., 2514 N. Frederick Ave., Milwaukee, Wisc.

Sloane, Miss Virginia M., 2514 N. Frederick Ave., Milwaukee, Wisc.

Swanson, Mrs. C. E., 4531 Summit St., Kansas City, Mo.

Talbot, Mrs. K. H., 237 Kavanaugh Pl., Wauwatosa, Wisc.

Ullius, Mrs. F. W., 3445 N. Cramer St., Milwaukee, Wisc.

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The American Concrete Institute and Concrete Research*

BY DUFF A. ABRAMS

The American Concrete Institute is a working organization which depends for results solely on the voluntary effort of the members who give so freely of their time and experience in the work of its committees and in the preparation of papers and reports for the benefit of all.

Probably the most outstanding accomplishment of the year 1930 was the organization of many new technical committees and the increasing activity of the committees already organized. The Institute now has 71 technical committees made up of 218 individuals. Each committee has been assigned a well-defined field for study and report.

The committees are grouped under the following headings:

Research
Materials
Engineering Design
Architectural Design
Specifications
Construction
Shop Manufacture
Use Requirements
Joint Efforts

It is the purpose to cover the entire field of concrete materials and usage and to bring to the members the most reliable data, experience or opinion bearing on all phases of concrete work.

The method of appointing an author-chairman who is responsible for the initial form of the report, has been most successful. Before a report is submitted to the Institute it is reviewed by two or more critic members who are selected on account of special qualifications for the work at hand.

*Address of the President, 27th Annual Convention of the American Concrete Institute, Milwaukee, February 26, 1931.

Another outstanding event of 1930 was the completion of the first full year of publication of the new JOURNAL. Publication of the JOURNAL was begun in November 1929; the first 8 issues comprise Vol. 26 of the *Proceedings*. These 8 issues contained 1238 pages, by far the largest number of pages published in any year. Seven issues of the current JOURNAL, September 1930 to March 1931, contain 1294 pages.

The JOURNAL has been highly successful in meeting the needs of the Institute members. The Institute is no longer dependent upon one annual forum for discussion of its problems; it now has ten forums in addition to the annual convention. The papers published in the JOURNAL are of a high order of merit and will, no doubt, place this publication in the first rank of journals devoted to concrete.

An examination of the published *Proceedings* of the Institute from 1905 to 1931 shows some interesting and significant changes in the center of interest of the members.

A classification of the material in the proceedings for two-year periods at about five year intervals gives the following results:

	Per Cent of Total Pages of Papers and Reports					
Years Averaged	Re-search	Design	Con-struction	Speci-fication	Products Plant	Misc.
1905 and 1906	4	3	31	13	39	9
1910 and 1911	14	11	52	17	6	0
1916 and 1917	34	9	36	13	4	4
1920 and 1921	34	19	44	5	4	1
1925 and 1926	40	12	29	12	5	2
1930* and 1931*	50	18	17	13	2	0

*JOURNAL, Nov. 1929 to Feb. 1931

At the beginning most attention was given to products plants, construction and specifications, with little space devoted to design and research. This condition has undergone a gradual change during the quarter-century of the Institute's active life, until the present publications exhibit a predominant interest in research with the remainder nearly equally divided between design, construction and specifications. Since the beginning of publication of the JOURNAL 50 per cent of papers and reports have been devoted to research. In arriving at this figure *Abstracts* and *News Letters* were not considered.

Probably the most interesting phase of this change is that it has apparently come about without aim or guidance on the part of those responsible for the direction of the Institute, but rather as an unconscious adaptation of the work of the Institute to the greatest needs of its members.

It is my belief that the best interests of the Institute demand a still greater recognition of the function of research in our field to the end that the Institute may become the recognized clearing house for concrete research.

What is the field for research in the concrete industries? It is obviously impracticable here to attempt to present a detailed outline of future research, however, some of the broader problems can be touched upon. It can safely be stated that we shall never have an adequate basis for specifications, design and construction in concrete and reinforced concrete until we develop a sound theory. If we had a complete theory of concrete we should be able to calculate in advance all the properties and behavior of any concrete or reinforced concrete member or structure. At present practically every different mixture of concrete materials presents a new and unsolved problem.

Workability is the starting point of every phase of concrete work—yet the most fundamental phases of this subject are still undiscovered. What are the characteristics of the individual constituents of a concrete mix which dictate the amount of water which must be used in order to produce a mix of a given degree of workability? There must be well-defined characteristics of the materials which can readily be measured which will give us the answer to this problem. What influence has the specific gravity of the cement, and its fineness and composition? What are the characteristics of the aggregate, size and shape of particles, specific gravity, surface condition? What properties of the water (surface tension, viscosity, fluidity, specific gravity)? In our previous studies of workability we may have kept too close to the problem. Suppose we broaden the problem and make it a study of the factors governing the plastic state of any granular material mixed with any liquid. In this case concrete becomes only a special case of a much broader problem. I believe it is only along such lines that we will learn the true principles underlying workability of concrete.

There are many differences of opinion regarding the relative merits of different types of aggregates which would no doubt be reconciled by adequate research.

A similar analysis should be made of the elements of concrete mixing. What are we endeavoring to accomplish when we put a batch of concrete in a mixer and turn it over for one minute? No adequate theory of concrete mixing has been presented.

There is need of a better correlation between cement tests and the properties and behavior of the same cements in concrete.

There is much work to be done in the development of proper methods and mixtures for concrete floors.

The committee on Properties of Mass Concrete has pointed out many new problems, most of which have not yet been touched upon in previous investigations.

The studies made by our committee on Durability of Concrete have been made by the members of the committee and presented to the Institute as a voluntary contribution. It is doubtful if the entire annual budget of the Institute would have been sufficient if we had been called upon to pay the cost of this work.

The reports presented at this convention by the committee on Reinforced Concrete Column Investigation is an excellent example of the manner in which the Institute can sponsor research projects. This program of tests carried out at the University of Illinois and at Lehigh University will involve an expenditure of about $40,000.00, all of which has been contributed from sources outside the Institute. If the Institute were required to pay all the costs of such a program the cost would have been double the figure given. It was only due to the interest of the Universities and the loyalty of the men in charge to the Institute and its aims that this work could be carried at an expenditure which represents only the cost of labor and materials.

The Institute has no research laboratory, it has no research staff, it has no funds which are adequate to finance an extensive research program, yet it has at its disposal many research laboratories and in its membership most of the leading experts on concrete. Experience in the column tests has shown that adequate funds can be secured for a well-considered program of tests. If all these factors can be brought together, it will furnish

a method of adding immensely to our knowledge of concrete and concrete materials.

We hear a great deal about over-production; however, this condition is not yet apparent in the field of research.

Mr. Walter Lippmann, Editor of the New York *World*, a keen observer of modern life, has pointed out that the most remarkable development of the past 25 years is not the machine age or mass production, but rather that men have discovered how to make discoveries. In other words, research has been reduced to a formula. Any engineering problem can be solved if we have the will to solve it.

This view should encourage us in the belief that our problems can be solved if they are attacked with skill and courage.

While it is natural that I should emphasize the importance of research, I do not mean to minimize other phases of our work, such as specifications, design, construction and shop manufacture. However, research covers all of these departments and is, in fact, of no value until it is translated into office and field usage. Research is the handmaiden of design and construction. The writing of adequate specifications will become child's play when we have at hand adequate information upon which to base the various requirements; this information can be furnished only by research.

Studies of Concrete Mixtures*

BY S. C. HOLLISTER†

In the course of concrete mixing and placing it has been the experience of many that there are occurrences in the behavior of the mixture that are not readily explained by the customary concepts of mixtures. For example the following queries arise from experience in concrete mixing:

1. What causes the "fatness" that is acquired by concrete mixtures on prolonged mixing or working?
2. Why is there sometimes a crazing and checking of trowelled surfaces?
3. What causes shrinkage?
4. Why is there a change in consistency of mix on prolonged mixing?
5. Why is there frequently a lack of bond between coarse aggregate and matrix?
6. Is there any relation between heating during prolonged mixing and the physical state of the mix?
7. Why does prolonged rodding improve the strength of concrete?
8. Is uniformity of consistency a measure of the desirable objective of the mixing process?
9. What are the characteristics of cements that often affect the mixing, placing and handling of the concrete mixture?
10. Can water be withdrawn from mix after placing—how much can be withdrawn safely and what is the result?

These and other problems arising in the concrete craft are not in the writer's opinion explained by the customary concepts of the composition of a concrete mixture during its workable state.

It is the purpose of this paper to relate many of the phenomena mentioned above, through the medium of a more detailed concept of the concrete mixture prior to hardening.

Concrete in a structure consists of an arrangement of variously sized inert particles called aggregates bound together by hardened cement. At the time of casting, concrete consists of the aggregates, cement and water. The change from wet concrete to

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†Professor Structural Engineering and Assistant Director Materials Testing Laboratory Purdue University.

hardened concrete involves the chemical activity of the cement made possible by the water present in the mix. The quality of the finished concrete is dependent upon the amount of cement, the amount of water and the nature, size, amount and gradation of the various aggregates.

There are two major characteristics by which the concrete mixture is usually judged; (1) its placeability and (2) its strength. A concrete for a given purpose must first of all be of such a plasticity that it may be properly placed. After it is once placed it is then judged by its strength and other correlated qualities. In both these characteristics the amount of mixing water is of prime importance. Anyone with practical experience knows the relation of water in producing a workable mix. Abrams[1] has established the dependence of the resulting strength primarily upon the relationship of the amounts of water to cement. Talbot and Richart[2] developed in the mortar-voids method of proportioning the same relation in another form.[3]

In the practical use of concrete the workability of the mixture is of especial importance. It is not only dependent upon the amounts and forms of the dry ingredients, but also upon the amount of water used in mixing, and especially upon the consequences of wetting these ingredients when considered together with the circumstances of mixing and placing. Thus the study of the train of events attendant upon the addition of the water assumes increasing importance. Stress is laid upon the importance of considering the ingredients *as they occur in the mix*, and the effect upon such occurrences of the various circumstances common to the mixing operation.

WATER AND SAND

When a grain of sand is slightly moistened two things transpire: (1) a small portion of this water is absorbed into the body of the grain of sand; and (2) the unabsorbed water surrounds the grain of sand in a film, which film is held in position by the force of surface tension.

When two grains of sand are moistened and brought together they are prevented from making direct contact by the film of water. If the amount of water surrounding the two particles is

[1]References are listed at the end of tnis paper.—EDITOR.

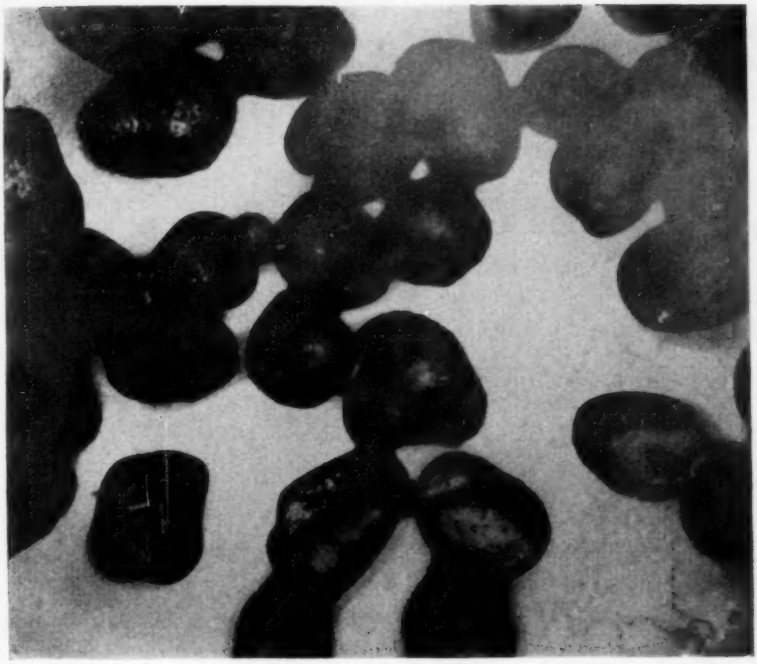

FIG. 1—LIQUID FILM ON GRAINS OF STANDARD OTTAWA SAND

small there is an insufficient amount of water to form an envelope to encompass both particles at once. Instead each grain is covered with an independent surface film which undertakes to maintain its separate form. The consequence is that the film of water holds the two particles from coming in close contact, because each grain behaves as though it were now larger than originally by the increase in diameter of the thickness of the water film. (See Fig. 1).

If the water surrounding these two particles is now gradually increased this excess water collects in the neck between the two grains and the water surface now tends to form a "peanut shape" surrounding both particles. It is now seen that a considerable amount of surface tension is acting to pull one particle toward the other. Under such conditions the two particles are no longer held apart.

The above discussion explains why dry sands are increased in bulk upon gradual moistening and why upon further increase of moistening a point of maximum bulking is reached beyond which further increase of moisture gradually diminishes the bulking until it almost entirely disappears.[4]

It can be demonstrated that for a given liquid the amount of moisture required to produce maximum bulking in a sand also the amount of the bulking are functions of the surface area of the sand.[5] A fine sand bulks more than a coarse sand and requires more liquid to produce this bulking because the surface area is greater for the fine sand.

A given sand will, of course, readily support the moisture required to produce maximum bulking without tendency of this moisture to drain off. This amount is not sufficient to produce a consistency in the wet sand comparable to that of the average concrete mixture.

WATER AND COARSE AGGREGATE

Assuming an impervious material, when gravel is moistened a film of water is formed on the surface of each particle in much the same manner as the film of water is formed around the grain of sand. For a given amount of gravel the surface area of the particles is less than for the surface area of a similar volume of sand. The amount of water necessary, therefore, to moisten the given volume of gravel (that is, to produce the film on the surface of the particles) is very much less than for the same volume of sand.

Whatever water is necessary to wet the surface of the gravel particles will not be sufficient to produce an appreciable mobility of the gravel. If, however, this wetted gravel be combined with a little more than enough of the wetted sand than would be required to fill the gravel interstices greater mobility will result. Even this amount of water, however, will not produce a workability such as is desired for concrete.

If the stone possesses much absorptive power at the time of wetting, a considerable amount of water will be taken up in saturating the stone. If the absorption is rapid, additional water must be supplied in order to give lubrication to the stone in the

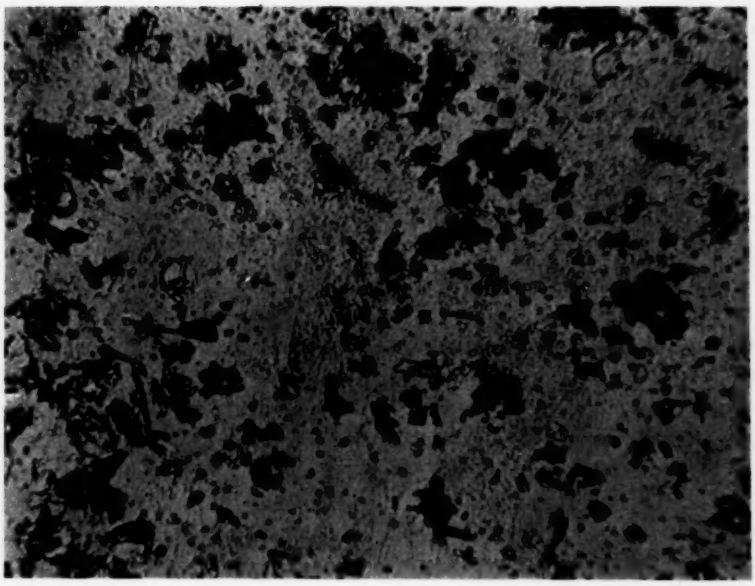

FIG. 2—DISPERSION OF CEMENT IN WATER (x275)

mix. On the other hand if the absorption is slow, less water will be needed by the stone to render it workable in the mix.

The shape of the stone particles not only affects the ease with which these particles move over one another in the mix but it also affects the amount of water required to wet the surface.

WATER AND THE CEMENT

The wetting of cement is a considerably different phenomenon from the wetting of sand. One need only think of the relative diameter of a grain of cement to the thickness of the water film to realize that a cement grain would be entirely inundated by such a film.

As shown in Fig. 2 the cement particles are of varying size and the fine particles tend to cling to the surface of the larger ones. When water is brought into contact with such a cluster of particles it engages the entire cluster, because the thickness of the surface film of water is relatively so large there is no tendency to separate

or disperse the particles and wrap each one individually with a film.

While in this instance an excess of water was present in order to obtain proper illumination, the tendency of cement to occur in clusters has been observed in a mass of more compacted structure. In either case as the water was quickly evaporated the voids between grains of cement are readily discernible.

THE MECHANICAL MIXTURE

Let us now bring together the three ingredients: the wetted gravel, the wetted sand and the wetted cement. Our first consideration is the mechanical arrangement of these wetted particles to produce a uniform dispersion. The sand grains fill the interstices between the particles of gravel, and in addition force the particles of gravel somewhat apart. The cement particles are to be found in clusters adhering to the particles of sand and gravel. The water exists in a film around the sand grains, the particles of gravel and the clusters of cement.

It will be found that where the water is just enough in amount to produce these films the mixture will be too stiff a consistency for proper working. Any additional water stirred into the mixture must occur in the small interstices remaining between the wetted particles of ingredients. This water may be termed "free water" in the mixture. Its only function is to aid in producing workability.

It should be noted that the water producing the film on the several ingredients is there for the sole purpose of producing workability for the mixture with the single exception of the water assigned to the cement. It is now important to consider the reaction between the cement and the water assigned to it and the effect upon the cement of all other water occurring in the mixture.

THE HYDRATING PROCESS

When water comes in contact with cement there is begun a long train of events, the conduct of which is the deciding factor in the extent to which this cement may impart strength to any given mixture. These events may be divided into two groups: those occurring prior to solidification and those occurring after solidification. It is not the purpose of this paper to go into

detail concerning the events in the second group. A large amount of research has already been done to determine the nature of such activity and the results of these researches have been published elsewhere.[6, 7, 8, 9] It is, however, desirable to develop here the processes occurring prior to hardening of the cement because it is while those processes are going on that the manipulation of the given mixture is possible. Whatever is accomplished prior to hardening will, of course, affect the processes subsequent to hardening, and conversely, what is left undone during the period in which manipulation is possible is not recoverable subsequent to hardening.

The question has often been raised whether a film of air is entrapped when the water first encompasses a cluster of cement grains or a single grain. The writer has been unable to observe under the microscope the presence of any such film. It is quite certain that the process of colloidal formation begins very soon after the water is added. If there is a film of air, therefore, separating the water and the cement it is very likely that this air is absorbed by the water. If this were not so and the air was present it would indeed be very difficult to initiate the colloidal formation.

If water is added to cement and is at once rapidly evaporated there is evidence of a cementious action having taken place. It would not appear that this could be so if there was an insulating film of air about the cement, unless this film of air were rapidly broken down. It is the writer's opinion that in either case the film of air, if at all present, is not of great consequence in our present consideration.

The water begins to dissolve the surface of the cement particles in contact with it. The substance thus produced in solution forms a jelly or colloid.[10] The strength of this solution depends upon the amount of water immediately at hand, which water causes in proportion to its amount a dilution of colloidal substance.

Observation of successive stages of colloidal formation and behavior develops many important facts which explain other phenomena noted in the process of mixing and handling the concrete mass. The amount of water usually present under ordinary conditions of mixing is greatly in excess of the amount of water

necessary to hydrate the cement. In addition to this water immediately in contact with the cement particles there is the large amount of water on the surface of the sand and coarse aggregate particles.

For some minutes after the water has come in contact with the cement no change is visible in this water. Gradually the water develops a variation in density so that it appears to wrinkle, giving much the appearance of wavy window glass. Then quite suddenly the waviness becomes very pronounced so that it looks like a shrunken film of varnish. At this point the formation of the colloid is quite well advanced. It is important to note that throughout this process of colloid formation the cement particle does not dissolve but remains as a nucleus in the colloidal mass.[13]

The action of the water in diluting the colloidal substance requires special attention. The more water present for a given amount of colloid the weaker that colloid. Furthermore the weaker the colloid the greater the amount of volumetric shrinkage upon the evaporation of the included water. Since the entire setting processes take place only in the colloidal substance present the weaker that colloid the less its physical strength. Fig. 3 shows clearly this phenomenon. The clusters of dark spots forming the boundary of the pattern in the figure are cement particles around which has been formed a rich colloid while these particles were submitted to hydration. Water extended over the entire area of this group and by this water colloidal substance distended, becoming the more dilute the farther it spread from the cement particles around the margin. Now, as the water gradually evaporated, all of the colloidal material shrank, the greatest shrinkage taking place in the central area of the pattern where the colloid was weakest. In this area the colloidal film thus formed was too weak to withstand the shrinkage stresses, hence producing cracks. It will be seen that these cracks are widest in the area of weakest solution and that they taper gradually and finally disappear as they approach the marginal area in which occurred the rich colloid.

It is thus seen that the water occurring in excess of that necessary to form a rich colloid becomes a rapidly weakening influence. This would appear to support the soundness of the physical law enunciated by Abrams that the strength of a port-

FIG. 3—CRACKING OF SHRUNKEN COLLOIDAL FILM DUE TO GROSS EXCESS OF WATER (X450)

land cement concrete mixture is a function of the ratio of the amount of water to the amount of cement in the mixture.[1]

While the above described phenomenon is taking place about the particles of the cement, other physical changes are taking place in a concrete mixture. From the time the colloidal "syrup" begins to form there is a gradual rise in the temperature of the mixture. This rise appears to continue until the stage of gel-formation, at which point the rate of temperature rise increases for some minutes. Thereafter the former rate of temperature rise continues up to the beginning of hardening. The consistency of the mixture during the period of colloid formation remains nearly

the same with a slight reduction in slump. At the time of gel-formation the consistency is noted markedly to stiffen. Thus a mixture with a 4-in. slump may stiffen to a 1-in. slump or less on formation of the gel.

With the use of a blend of two standard portland cements at a room temperature of 70 deg. F., evidence of "syrup" was noted from 10 to 15 minutes after the water was brought upon the cement. The gel state occurred at from 40 to 45 minutes after wetting the cement. These values are different for different brands of cement.

Whether the "syrup" or gel mentioned above represents the hydration of aluminates only, prior to hydration of the silicate group, or whether both are proceeding simultaneously or whether the state noted originates from another source than those just mentioned the writer cannot say. For the purpose of this paper the significant thing is that there is this jelly-like substance surrounding the cement particles and that its presence has a bearing upon the workability of the mix.

Another test was made to determine the volumetric effect on a block of neat cement of the shrinkage of colloidal substance noted in Fig. 3. A given amount was mixed with a gross excess of water and agitated from time to time for a period of six hours, after which it was allowed to settle and harden. It was noted that the upper portion of the mass of cement was "fat" and slimy, whereas the lower portion was very much less fat. Upon hardening in a smooth glass container it was found that a glaze formed next to the glass, and that this glaze, at three days, had developed a considerable adhesion to the glass. Upon air curing there appeared checks in the top face and these checks developed into cracks extending down halfway from the top face. (See Fig. 4.) The cracked portion was that portion formed of excessively wetted colloidal substance noted before setting took place.

It should be noted that the amount of water was far in excess of that in a concrete mix and that the amount of shrinkage is not at all comparable to that to be found in concrete unless placed under water. The significant relation is that between shrinkage and excessively wetted colloid, and that such colloid is readily floated to the top surface of a mix, when the mix is wet, or when

it is considerably agitated. Over-working of the top surface by troweling or otherwise will promote this accumulation of "fatty" mortar and if dried too rapidly will produce cracking. Many floors and sidewalks have exhibited this tendency.

Microscopic examination of the glazed surface above mentioned disclosed cracks in the glaze itself soon after exposure to the air.

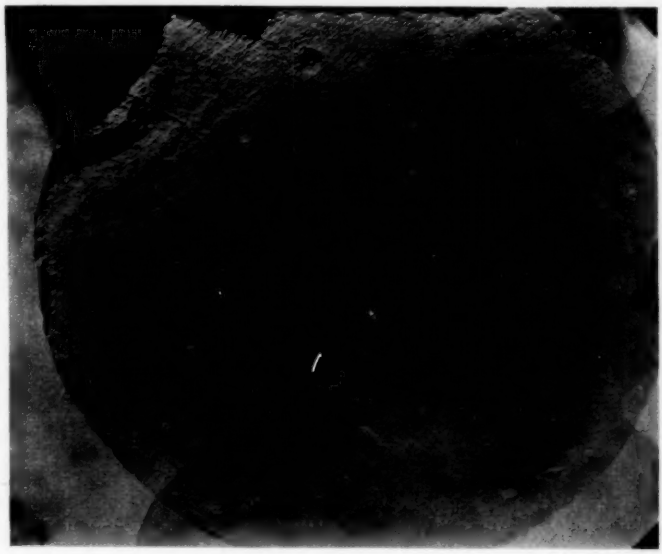

FIG. 4—CRACKS IN BLOCK OF NEAT CEMENT CAUSED BY GROSS EXCESS OF WATER

It would appear that there is a relation between crazing or surface checking and the shrinkage on loss of water in excessively extended colloidal substance collected at the surface. Technique which would tend to work the colloidal material *away from* the surface to be exposed would seem to reduce the occurrence of crazing.

Shrinkage on drying of a concrete mass, aside from temperature effects, would seem to be related to the richness and wetness of the mix, since these factors are the elements involved in extent of colloidal formation.

The foregoing test indicates one other important action.

Excess water does not produce more colloid of the desired richness, but instead dilutes (and hence weakens) such colloid.

The question now naturally arises, What is the relation between water and colloid? If the colloid goes into solution the escape of such solution would also mean the escape of what was originally colloidal substance, and there would consequently be a loss of strength proportionate to such escape.

W. I. Freel, of the Materials Testing Laboratory at Purdue University, made some tests to determine the solubility of cement in water. He found that the agitation of cement in an excess of water for various periods of time followed by settling of cement particles until the top liquor was clear, produced a top liquor which when decanted had a specific gravity of unity. This would indicate that the colloidal substance does not go into solution, but instead, is diluted but not dissolved by the water.

Tests were made to determine whether the liquor formed by the method used by Mr. Freel would show any sign of cementious characteristics when mixed with a known sand to form a mortar. No cementing ability was found by such tests.

FACTORS ARISING FROM CHARACTER OF AGGREGATE

There appear to be various views among investigators as to the proportion of strength of concrete contributed by the mortar and by the coarse aggregate. The coarse particles cannot contribute to the strength of concrete unless a bond between them and the mortar can be established.

As previously described a film of water is present on the surface of the coarse aggregate at the beginning of the mixing operation. Particles of cement lodged against this film cannot readily penetrate it. And for the number of such particles there is too much water in the film to admit of a satisfactory degree of colloidal strength being formed in the film that will reach through the film to the surface of the aggregate.

If this film of water cannot escape until after final setting a poor attachment to the stone is effected by the mortar. That such poor attachment is often obtained in concrete is shown by the fact that on fracture numerous examples occur in which the coarse aggregate itself is not fractured but instead pulls away from the matrix.

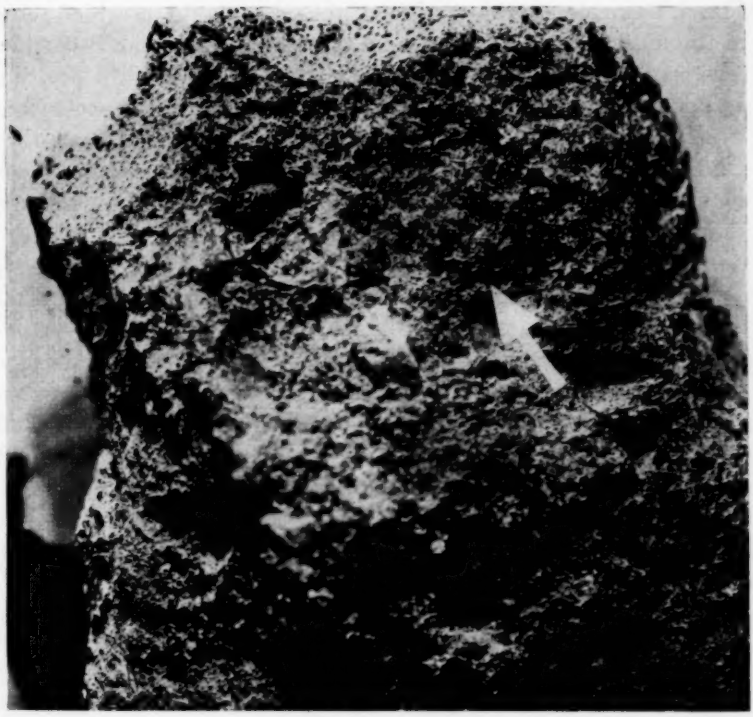

FIG. 5—WATER VOIDS AGAINST BOTTOM OF COARSE AGGREGATE IN OVER-WET MIXTURE

A microscopic examination was made of numerous specimens of which on the one hand the aggregate had pulled away and on the other the aggregate had fractured. In general it was found that where the aggregate pulled away a slight glaze was noticeable on microscopic examination, this glaze being similar to that formed by cement colloid alone upon evaporation of the moisture. Examination of the socket in the matrix out of which the aggregate was removed showed a surface consisting of very fine particles of sand together with the cement, the whole surface displaying a pitted sugary structure.

It is exceedingly difficult to obtain a satisfactory photograph conveying a correct impression of the observation made on the plane of contact between mortar and certain types of stone.

Fig. 5, however, is a piece of over wetted concrete on which some of the faults of excessive water just described are plainly visible. The concrete specimen was photographed in its upright position as cast. At the top are plainly seen portions of two sockets from which the stone fell away from the matrix. Arrows point to voids existing along the underface of a fractured stone. Voids such as these are often found in mixtures less wet than the one shown in the figure, especially if the aggregate has low absorption at the time of mixing.

A comparison of the properties of aggregates before and after use in concrete indicates clearly that for the particular types of stone observed, the bond to that stone was effected by sufficient available absorption on the part of the stone to pull in the water forming the film. Fracture of such absorbent stone was effected if the matrix was as strong as, or stronger than, the stone itself.

The effect of the absorption of water by the aggregates in affecting the strength of the concrete was found to result in an increase in the strength of such concrete commensurate with the change in the water cement ratio.

Increase in strength made possible by lowering the water cement ratio through the use of absorbent aggregate gives rise to speculation as to possible improvement in the quality of concrete produced by removal of excess water by this or other means. The investigations of Pearson[11] at the Bureau of Standards upon portland cement stuccos indicates the importance of the removal of water from the fresh coat by the proper amount of absorption by the undercoat. The same principle is involved in the use of sand molds in cast stone work. The undesirable results of excessive absorption by untreated gypsum molds indicates the necessity of control of such absorptive processes. The technique developed in the studio of John J. Earley[12] involves, in part, removal of excess mixing water through controlled capillary absorption.

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CONVENTION DISCUSSION

W. A. SLATER—Mr. Hollister has spoken of the development of something like a jell around the cement, as one of the agents in producing workability and that the effect is greater after continued mixing. I raise no question as to that. I do not know anything about it, I have to admit, but I want to call attention to a development within the last few weeks at Lehigh University. We were testing a conveyor designed to transport concrete from the central mixing plant to the place where it is to be used. It is a closed drum conveyor. A mix was designed using seven gallons of water per bag of cement. We charged the conveyor and at various intervals from the time of leaving the laboratory, for two and a half hours, samples were taken from the drum and analyses made of them, separating the ingredients into their various constituents and measuring them. We found that the amount of cement apparently increased until, after two hours and a half, from our measurement we would say that we had about thirty to forty per cent more cement than when we started out. We were not being fooled entirely, because the amount of water remained constant, the amount of sand decreased and the amount of decrease in the sand was just about the same as the amount of increase in the cement. We concluded that we were grinding up the sand as we went along, but the point I wanted to call attention to particularly was that the slump regularly decreased from the beginning until the end, although the amount of water remained constant. We concluded that the amount of material ground up in the operation had an important bearing on the amount of slump. It is entirely possible there were other factors at work too, but I think that must have had something to do

with it. Having nothing to do with this particular part of it, but as a matter of interest, the strength also increased as the time from the beginning of the transportation increased. I do not remember how much but it was a very substantial increase for the specimens taken after two and a half hours over those taken at the beginning.

P. H. BATES—I am particularly pleased to see that Professor Hollister is injecting a little physics into his engineering course because I think if his students once sense that this whole matter of making concrete is chemistry, and chemistry a branch of physics, we will have gotten around to the fundamental basis on which to study concrete.

Professor Slater cites the interesting discovery that in mixing concrete he made cement. Nearly 20 years ago a well-known contractor in Pittsburgh had a contract for grouting some veins in a mine shaft in order to prevent leakage of the water into the shaft. After some time he noticed that the bottom of the shaft in which he was not supposed to do any grouting was filling up, and he had to stop his grouting He measured the amount of grout he had in the bottom of his shaft and found that it was many times the amount of cement he had purchased, and he was very much alarmed about the whole matter.

I think we have got to realize that this matter of the setting of cement is a colloidal phenomenon, nothing more nor less, and will have all the characteristics of a colloidal material. You can assume it is an inorganic glue (probably you are sitting on a chair fastened with an organic glue) and you know exactly what happens when you do not treat an organic glue properly; if you use too much water or not enough, it does not glue. It is the same way with cement, and runs through many, many similar phenomena. A great many of you have noticed the work done by Miller at Minneapolis, the effect of alkali on concrete. If he cures concrete at a high temperature and puts it in alkali, it is almost immune to attack. You can dilute the white of an egg with water indefinitely, but if you once subject it to a high temperature, it is no longer soluble. Professor Miller probably has done that in treating his concrete at a high temperature.

For further discussion which may develop, see JOURNAL *for Oct., 1931 (Vol. 28.) Such discussion should reach the Secretary by Sept. 1, 1931.*

The Use of Color in Concrete*

Progress Report of Committee 408—Recommended Practice in the use of Color in Concrete

W. D. M. ALLAN, CHAIRMAN

INTRODUCTION

The American Concrete Institute appointed Committee 408 in July, 1930, to draft a Recommended Practice for the Use of Color in Concrete because of the growing demand for information on this subject.

The principal classes of color materials are: 1. Pigment admixtures; 2. Selected aggregates; 3. Chemical stains; and 4. Water and oil vehicle paints.

The Committee planned to make each of these sections the basis of a separate report or to suggest to the Institute that committees be appointed to cover each one.

Of the four classes of color work, there is most urgent demand for information on the use of pigment admixtures in troweled concrete surfaces which is the basis of the Committee's first report. Based on a study of the whole problem of the use of color in concrete, the Committee suggests the following subjects which might be developed as additional separate reports:

Pigment admixtures

1. In monolithic concrete walls
2. In cast stone and precast units.
3. In stucco and mortar

Selected aggregates

1. Color possibilities of natural aggregates.
2. Color possibilities of manufactured aggregates.
3. Combination of colored aggregates and colored mortars.
4. Surface treatments of concrete to develop color value of aggregates and mortar.

*Presented at the 27th Annual Convention, Milwaukee, Feb. 24-26, 1931.

Chemical stains

1. Chemical composition of stains and reaction with concrete to produce color.
2. Application of chemical stains to concrete surfaces.

Paints

1. Composition of water and oil vehicle paints.
2. Application of paints to concrete surfaces.
3. Protective value of paints on concrete srufaces.

Much has been written in technical papers on these subjects and a great deal that is of value has been presented to the American Concrete Institute which could be assembled under proper headings, supplemented by more recent information and put into usable form.

In presenting this recommended practice for the use of pigment admixtures in troweled concrete surfaces, the Committee has followed each section where it seemed desirable to do so with a sub-section of discussion. This method makes possible the inclusion of explanatory material for those who desire it, without making unnecessary reading for those who are interested only in the specific recommendations.

The Committee hopes that a large number of members, users and manufacturers interested in color, will comment freely on all parts of the following proposed recommended practice to the end that all who desire to get thoroughly permanent colors in their troweled concrete work may do so.

There are several points in this report upon which there is important division of opinion, e. g., several members feel that the use of the dust coat is sufficient to produce satisfactory work; while others feel equally certain that the dust coat is to be avoided on all but unimportant work. It must be admitted that many satisfactory dust coat jobs have been produced and in the hands of skilled workmen with close supervision, this method has possibilities. On the other hand, it must be admitted that excess of fines on the surface of concrete wear or weather surfaces leads to dusting and crazing. No satisfactory basis has yet been developed for evaluating these two ideas or arriving at the proper method of handling. From the anticipated discussion in the JOURNAL and from suggestions and criticisms received direct by committee members, it is hoped to be able to present for

adoption, a Recommended Practice for tentative adoption at the 1932 convention.

Progress Report on a Proposed Recommended Practice for the Use of Pigment Admixtures in Troweled Concrete Surfaces

PURPOSE

This recommended practice is designed to furnish the best information available on the selection and handling of pigment admixtures, laboratory tests for their quality and methods of using pigments in troweled concrete surfaces.

PART 1

General Requirements for Pigments

Only inorganic pigments, as limited in this section, should be used in troweled concrete surfaces. Synthetic and natural mineral pigments are satisfactory if they meet the following requirements:

1. Insoluble in water.
2. Free from soluble salts.
3. Free from acids.
4. Fast to intense sunlight.
5. Fast to heat up to 300 deg. F.
6. Not to exceed 2 per cent by weight of free moisture.
7. Fast to alkali and weak acids.
8. Free from calcium sulphate in excess of 15 per cent by weight.
9. At least 90 per cent of synthetic pigments pass a 325-mesh sieve and at least 90 per cent of natural pigments pass a 200-mesh sieve.

Discussion—The manufacturers of concrete pigment admixtures should be in a position to guarantee that materials meet these requirements. The test procedure which appears as appendix to this report will assist the purchaser in getting a prompt report from a recognized testing laboratory covering the suitability of a pigment based on the requirements above.

Synthetic pigments usually have a high degree of purity and uniformity. They are more brilliant and the cost per pound is usually higher than for natural pigments. For particularly important jobs and where brilliant colors are desired, synthetic pigments are recommended. For dull colors, natural pigments meeting the requirements above will be satisfactory, provided the amount of pigment added does not reduce the quality of the concrete so that it will not resist wear and weather. Frequently the smaller amount of syn-

thetic pigment at a higher price per pound will produce the results desired at a lower cost than the natural pigments.

In general, the finer the pigment the greater its coloring value.

Calcium sulphate sometimes occurs as a filler in pigments and it is necessary to limit the amount because of the detrimental effect of the sulphate on the concrete.

Some pigments have the property of absorbing moisture from the air and care should be taken to keep them dry; otherwise, they will be lumpy. When they are mixed with cement and stand for some time before being used, the moisture may react with the cement to cause caking. The limit of 2 per cent of moisture is intended to apply to the free moisture in the pigment and not to chemically combined water.

Selection of Pigments

Red—Use either synthetic or natural oxides of iron.

Yellow—Use synthetic yellow oxide of iron.

Buff—Use either natural or synthetic yellow oxides of iron.

Brown—Use synthetic or natural brown oxides of iron.

Black, Gray—Use synthetic black iron oxide.

Green—Use only synthetic chromium oxide; Cr_2O_3, at least 98 per cent pure.

Blue—Use synthetic cobalt blue at least 98 per cent pure and free from sulphates.

Methods of Test

Wherever iron oxide pigments are required, the purity shall be at least 98 per cent iron in the form of Fe_2O_3 after ignition at from 900 to 1000 deg. Centigrade for synthetic pigments and for natural pigments, the purity shall be at least 55 per cent, determined in the same manner.

Pigments shall be tested for purity in accordance with the test procedure in the appendix to this report.

The amount of pigment shall not exceed the proportions of 12 pounds of pigment to one sack of cement, (94 pounds net).

Discussion—In general, the least pigment used to obtain the desired color value, the better. This is especially true of surfaces that are to be subjected to heavy wear or to water or frost action. When necessary to use the maximum amounts of pigment shown above, special care must be taken to place the colored concrete with a minimum of water, to increase the time of mixing and to get more than average curing.

The recommendation for the use of synthetic black oxide of iron is based on the difficulty of getting definite non-fading black color with other blacks frequently used. While some organic blacks have and maintain a deep black

color they are light and fluffy and difficult to mix. If sufficient time and care are taken to obtain a thorough mix they are satisfactory. Not more than 3 per cent by weight of cement of organic pigment should be used. Cobalt blue is recommended in preference to ultramarine blue because of the large amount of fading which in cases has resulted in a total disappearance of the color when the ultramarine blue has been used. For specific jobs where some fading is not objectionable and where the manufacturer will guarantee the durability of the ultramarine blue, within reasonable limits of fading, it may be used under the manufacturer's direction.

Pigments used as admixtures in concrete must be considered as fine aggregate. Experience shows that because of the fine grading of the pigment, which is desirable for color value, it dries up the mix rapidly, leading to the tendency to use more mixing water. This, in turn, reduces the cementing value of the cement paste and results in inferior concrete. As the amount of pigment is increased, it is desirable to decrease the amount of fines below the No. 50 mesh screen in the aggregate used. Care must be taken not to increase the amount of mixing water used per sack of cement, above that required to produce concrete of the quality needed for the job if it were not be colored.

Color Value of Pigments

No table of definite color values can be given for pigments in concrete. It is necessary for the user to prepare sample panels of convenient size and combine the pigment in various accurately weighed amounts with a definitely known amount of cement, aggregates and water, such as he will use on the job. All proportions must be accurately made and the whole mass thoroughly mixed, placed and finished exactly in the way it will be done on the job. The panels should then be cured in the same manner that the job will be cured and then allowed to dry. The surface of the panel should then be wiped off with a mixture of one part paraffin oil and one part of benzine or similar vehicle and allowed to dry. From these sample panels, the color values possible with different materials and combinations can be determined and then, by reference to the data covering the method of producing the original panels, the color can be duplicated within very narrow limits.

Discussion—Color values cannot be established except by trial because the fineness of the pigment, color of the cement and aggregate, quality and quantity of the mixing water, time of mix, amount of troweling and method of curing all affect the values obtained.

A record should be kept of the exact proportions used in each panel so that the results can be duplicated. If the source of any of the materials is changed, a new series of panels should be prepared. A slight variation in either pigment,

cement, aggregate, water or method of mixing, placing or curing will produce variations in the finished job.

Some members of the committee have strongly urged that some standard of color values should be developed. A standard color chart has been suggested and all colors could be graded as 100 plus or minus depending on their tinting value.

Another suggestion strongly advocated is that the color values be taken from color charts prepared by the manufacturers and the concrete prepared and placed according to the directions of the manufacturers. The committee does not wish to rule against either of these plans but it recognizes that neither of them is feasible at present and the problem raised is important and needs solution.

Blending Pigments

Considerable skill and adequate equipment are required to blend successfully two or more pigments. Contractors and other users of pigments with a good "eye for color" can enlarge the range of colors available by blending or mixing the primary colors. This is frequently necessary on polychrome jobs and where slight variations in colors are desired. It is recommended that blended colors be purchased from reputable color manufacturers unless the user is sufficiently experienced and equipped to blend his own pigments. An accurate record of the exact amounts of colors used, weighed to the nearest ounce, for one-sack batches is absolutely necessary to get satisfactory results with blended colors.

Proportioning Pigments

All the materials entering into the batch must be carefully weighed. The quantities of pigment and other ingredients to be used are determined from the sample panels. Uniform results require that every batch be proportioned, mixed, placed, finished and cured exactly like every other. Even though the aggregate, cement and water may be measured by volume, the pigment must be measured by weight.

Discussion—Measuring pigments with a dipper or by any other volume method may be satisfactory for rough work where uniformity and high grade wearing surfaces are not required but this method is unreliable even with skilled workmen for important jobs. If the pigment has to be mixed on the job the color at least should be weighed out accurately at the plant or shop and delivered to the job in containers, each one containing just enough pigment for each batch.

Mixing Pigments

Pigments must be thoroughly mixed with the cement and with the cement and aggregate to get uniform work. There are several ways in which the pigment and cement can be mixed and the methods are described in the order of their value:

The color mixer, which is a tight, revolving metal drum with stationary paddles or blades, or a stationary drum with revolving paddles or blades of sufficient capacity to hold one-half, one or more sacks of cement with the pigment, is the best method for mixing pigments. The cement and pigment are accurately weighed and placed in the mixer and mixed for not less than ten minutes. When the batch is mixed it is sacked and kept dry until it is used.

In the absence of a color mixer on important work, it is recommended that factory-prepared colored cement be purchased from a reputable manufacturer.

Another method that will prove satisfactory if care is used, is to mix the accurately weighed proportions of cement and pigment by passing the two materials through a ⅛-inch screen several times until all particles of pigment are thoroughly incorporated with the cement. This should be done at the plant where the materials can be kept dry and where weighing equipment is available.

Another method of mixing pigments on less important work is to use a concrete mixer. The aggregate and cement are put into the mixer and turned over a few times, then the measured amount of pigment is added in small portions, care being taken to get the pigment well distributed throughout the batch. This should be added in small quantities to avoid the danger of lumps forming which are very difficult to get thoroughly mixed. The mixing should continue until the pigment is uniformly distributed throughout the mass and then the water is added. The wet mixing should continue until the mass is of uniform consistency and the pigment is thoroughly distributed.

Discussion—Attempting to mix by hoeing together pigment and cement in a mortar box can produce satisfactory results only in the rarest cases and this practice should not be considered if uniform, reliable results are desired.

Regardless of the mechanical means employed, both the dry and wet mixing must be continued until the pigment and cement, or the pigment, cement

and aggregate are mixed to a uniform color. The best method of determining if the mixing has progressed long enough is to take a small amount of the material, possibly a shovelful and place it in a pan, wheelbarrow, or on a smooth concrete surface. Then spread it out in a thin layer with a trowel and trowel this thin layer hard. If streaks of pigment or cement can be seen, the mixing must continue until later trials show no streaking.

PART 2

Types of Troweled Colored Concrete Surfaces

In general, the use of color in troweled concrete surfaces can be divided into three approved types of construction:

Two-course monolithic construction, in which the colored top course is placed before the base course has hardened, so that the two courses harden as one-course construction.

Regular two-course construction, in which the colored top course is placed on a hardened base course.

One-course construction, wherein the pigment is used throughout the thickness of the section.

Discussion—Two-course monolithic construction is best practice wherever possible, because danger of a separation of the two courses is eliminated.

Regular two-course construction is used where it is not desirable to place the finish until some time after the base course has been placed.

One-course work is not common except in very thin slabs and in other work where only light tints are wanted.

The terminology developed for the three types of color jobs has been criticized as not definite enough. However, the changes suggested have been no improvement. Further study is needed.

Thickness of Colored Topping

For severe wear and exposure, the colored topping should be not less than 1 in. thick. For moderate wear and exposure the colored topping should be not less than ¾-in. thick. These apply to two-course monolithic work. For regular two-course work, all colored toppings shall be at least 1 in. thick.

Selection of Aggregates

Aggregates should be selected for grading, cleanness, durability and color.

For all severe wear and/or exposure, the aggregates should be composed of fine and coarse particles graded as follows:

Fine aggregate—All passing a ¼-in. screen, not more than 10 per cent passing a 50-mesh screen and not more than 3 per cent passing a 100-mesh screen.

Coarse aggregate—All passing a $\frac{3}{8}$-in. screen and all retained on a $\frac{1}{8}$-in. screen.

Aggregates should be hard, durable sand, pebbles or crushed materials free from dust, loam, clay or vegetable matter and contain no flat, elongated or flaky particles.

For moderate wear and/or exposure coarse aggregate may be omitted.

Aggregates should be selected from a source where the grading and moisture content remain uniform throughout the job.

Discussion—The grading of the fine and coarse aggregates should be such that there is a predominance of the larger sizes.

Where possible, the aggregates should be selected to match or strikingly contrast with the color of the mortar. When the mortar wears from the surface, the color of the exposed aggregate will have a marked effect on the color and appearance of the surface. Translucent aggregates, such as light colored, crushed marble, help maintain the desired color if the mortar surface wears away.

If the supply of aggregate is not uniform as to grading and moisture content, the user should screen his own materials and store them so that they are uniform.

Proportions of Cement and Aggregate

For severe wear and/or exposure, the proportions should be approximately one sack of cement, one cu. ft. of fine aggregate and two cu. ft. of coarse aggregate.

For light wear and/or exposure, the proportions should be approximately one sack of cement and two cu. ft. of fine aggregate.

The proportions of aggregate may be varied to correct for workability and consistency.

Discussion—The above proportions may have to be varied depending on the type of work, the grading of the aggregate and the amount of pigment used. In varying the proportions, as much of the coarse aggregate as possible should be worked into the mix. These proportions are on a damp and loose volume basis.

Mixing Water

Mixing water should be free from injurious amounts of acids, alkali, oil or vegetable matter and should be fit to drink.

The total amount of mixing water to be added with each sack of cement should not exceed 5 gal., including the free moisture in the aggregate. In adjusting the proportions of aggregate, correction for free moisture should be made.

Discussion—Impure mixing water, especially if it contains acids or alkali, may lead to efflorescence.

For particularly severe wear and/or exposure the total amount of water should be reduced to 4½ gal. per sack of cement. Accurate moisture determination for the aggregate must be made. When changing proportions of fine to coarse aggregate or of aggregate to cement, correction must be made in the amount of mixing water so that at no time the total amount of water added per one-sack of cement exceeds 4½ or 5 gal.

Consistency

Colored concrete for troweled surfaces should be placed as stiff as possible. The slump in no case should exceed 4 to 5 ins. Very little, if any water should appear on the surface when it is screeded or straight-edged.

Discussion—Stiff consistency is necessary to prevent the fine material coming to the surface during placing and troweling. The concrete should be stiff enough so that it has to be rolled or lightly tamped into place.

Mixing

Colored concrete, especially for two-course monolithic and regular two-course work, should be mixed not less than two minutes after all the materials, including the water, are placed in the mixer if the cement and pigment have been thoroughly mixed before being placed in the mixer. At least five minutes longer will be required for mixing if the pigment has not previously been mixed with the cement.

Discussion—The grading and proportions of aggregate recommended above, will tend to be more harsh than the average cement finisher is in the habit of working. Increasing the mixing time up to five minutes will improve the workability and at the same time increase the intensity of the color and improve the strength and wearing properties of the hardened concrete. The time of mixing for all batches should be the same.

Placing

Two-course monolithic and regular two-course work should be placed on bases that are clean and free from water. In *two-course monolithic* work, the base should stand until all the surface water has either evaporated or has been broomed or screeded off or removed in some other manner. All laitance or scum shall be removed before the colored concrete is placed.

In *regular two-course* work, the base should be broomed or cleaned and roughened just before it hardens. Before the colored concrete is placed, the surface should be scrubbed with water to remove all dirt. If there is oil or other foreign material on the

base, it should be removed with soap and hot water or with sharp edged tools. When the washed surface has begun to dry slightly, a mixture of cement and water or one part of cement and one part of sand mixed to a thick creamy consistency should be broomed onto the surface in a uniform layer about ⅛-in. thick. Before this grout coat begins to dry the topping should be placed.

The colored concrete should be deposited in small batches close together and screeded or straight-edged to grade. Special care shall be taken when straight-edging to fill up and prevent low places in the topping. The surface should then be wood floated and allowed to stiffen before the steel trowel is used. Areas of colored topping should be placed, small enough so that by the time of finishing all of the topping will have stiffened to the same degree.

Discussion—Any water on the base, whether it be from the fresh concrete or applied for washing, should be removed or allowed to evaporate before the colored concrete is placed. Otherwise this water will rise through the colored concrete, tending to cause efflorescence and dusting. In two-course monolithic construction the danger of water from the base rising through the colored topping will be reduced to a minimum by placing the base as stiff as possible.

Troweling

Steel troweling should be delayed as long as possible and still be able to finish to a smooth compact surface. Troweling should be reduced to a minimum and the final strokes be made all in one direction. Sprinkling the surface with water to aid in troweling should not be permitted.

Discussion—Any working of the surface even with a straight edge or screed tends to bring fines to the surface. Steel troweling is particularly bad. The surface should be worked as little as possible. Fines lead to dusting, checking and blotchy color. If the troweling is delayed until all the water sheen has disappeared and the concrete has stiffened slightly, the danger of drawing fine material to the surface is reduced to a minimum. Attempting to fill up low places by troweling surrounding material into them will result in discoloration and the tendency toward dusting. Low places should be leveled with the straight-edge and wood float.

Filling Low or Wet Areas

Filling in low or wet places with dry mixtures of pigment and cement or pigment, cement and aggregate should not be attempted. Steel troweling wet places should be delayed until the excess water has disappeared. Low places should be filled with a concrete mixture exactly the same as is being placed and care

must be taken not to work the concrete in the low places any more than any of the other surface. When filling a low place, the concrete for several inches around should be roughened and then brought back to grade along with the added concrete by using the straight-edge and float.

Curing

All colored concrete surfaces should be damp cured for not less than seven days. Where subjected to severe wear or exposure the damp curing should continue for not less than 10 days. The surface at no time during these periods should show any tendency toward drying. Ponding, completely covering with damp sand or with approved grades of heavy waterproofed paper or fabric should be required.

Discussion—Nowhere in concrete work is proper curing of more importance than in troweled colored concrete surfaces. Strength, resistance to wear, freedom from dusting and checking are as much dependent on proper curing as upon any one factor. In hot, dry or windy weather, the surface should be protected from the sun and wind immediately after steel troweling. The curing should be started as soon as the surface has hardened enough to prevent damage.

Surface Treatment

After the concrete has been cured as required above, it should be washed off with clean water and allowed to become thoroughly dry. If after washing a light colored deposit or film, called efflorescence or bloom appears on the surface or if the color seems to have faded, the surface may be dampened with water and washed with a solution of one part of muriatic acid to 10 parts of water. The acid is put on uniformly over the surface with a long handled brush or broom and allowed to remain for not more than five minutes, when it is entirely removed with an abundance of clean water. It may be necessary to repeat the acid treatment. The acid should not be allowed to remain long enough to start etching the surface and should not be used at all on heavy wear surfaces.

Efflorescence may be removed by steel brushing or rubbing with steel wool. The material loosened in this way should be broomed from the surface before it is washed or given any other surface treatment.

Rubbing the surface with a mixture of equal parts of paraffin oil and benzine or naphtha will remove the efflorescence if it is not too thick. This treatment is sometimes used to brighten the colored surface.

Washing the surface with liquid soap which has been allowed to stand overnight and then scrubbed off with warm water improves the colors and wearing surface. This treatment should be repeated two or three times over a period of four months.

Ordinary floor wax aids in brightening the colors and filling the surface so that it is more easily kept clean.

There are numerous other commercial waxes and resins which applied to the surface will aid in brightening colors.

This progress report has been submitted to the following committee, which voted as follows:

W. D. M. Allan, Chairman
C. A. Cooke
J. G. Ahlers
M. R. Rust
J. W. Ayers
E. M. Waldo
John Mott
Rexford Newcomb

Of whom 7 have voted affirmatively, one negatively and none has refrained from voting.

Respectfully submitted,

W. D. M. Allan

Chairman, Committee 408.

Appendix—Report Committee 408

Laboratory Test Procedure for Determining the Quality of Pigment Admixtures

Acidity of Pure Oxides

Boil five grams of pigment with 200 cc. of distilled water in a 300 cc. Erlenmeyer flask for 20 minutes. Cool under the tap and filter through a 15 cm. filter paper into another similar flask. Wash with about 40 cc. water. Add three or four drops 1 per cent phenolphthalein indicator, and titrate with $\frac{N}{100}$ sodium hydroxide.

Standardization of Sodium Hydroxide

Weigh accurately a convenient quantity (suggest .06 grams) of acid potassium phthalate $C_8H_5O_4K$ (obtained from the Bureau of Standards). Dissolve in cold water and titrate with the $\frac{N}{100}$ sodium hydroxide, using phenolphthalein as before.

The normality of solution equals $\frac{\text{weight } C_8H_5O_4K}{\text{burette reading x } 0.204}$

Percent H_2SO_4 in sample equals $\frac{\text{burette reading x .049 x normality x 100}}{5}$

Blank tests should be run on the water used both in standardizing and the actual determination.

Routine Test for Presence of Acid

A ten gram sample of pigment is allowed to digest in 150 cc. of distilled water one minute. Filter off the pigment and analyze the filtrate with methyl orange or phenolphthalein.

Test for Moisture

Weigh out accurately a one to three gram sample of pigment into a fused quartz crucible, which has previously been thoroughly cleaned, heated to a temperature of 125 deg. C. cooled in a desiccator, and weighed.

Place the crucible, with the material, in the electric furnace, and heat to 110 deg. C. for one and one-half hours. Remove from the furnace, place in desiccator until cool and weigh.

Computation: Loss of weight divided by the original weight times one hundred equals percentage of moisture.

Determination of Percentage of Ferric Oxide

Solution: Dissolve ½ gram oxide in about 20 cc. 1-1 hydrochloric acid in 100 cc. beaker. Add enough stannous chloride to keep the solution very nearly in the reduced state. (If solution is over-reduced, add enough permanganate solution to restore yellow ferric color.)

Reduction: When the solution is complete, reduce the ferric oxide by adding stannous chloride drop by drop until the solution is entirely colorless. Then add one drop in excess. Wash solution into a 400 cc. beaker containing 250 cc. of water, add 20 cc. titrating mixture and 10 cc. of mercuric chloride. Titrate with potassium permanganate to a permanent pink color.

Computation: Percentage of Fe_2O_3 = burette reading x normality factor x 200.

Potassium Permanganate Solution: About 4 grams per liter or of such strength as to give 1 cc. equal to 1/100th gram ferric oxide.

Stannous Chloride: 100 grams stannous chloride, 100 cc. concentrated hydrochloric acid, 100 cc. water. Make up to liter and add a few pieces of metallic tin.

Titrating Solution: 160 grams manganese sulphate, 1320 cc. sulphuric acid, 1.84 Sp. Gr., 330 cc. of syrupy phosphoric acid, 1750 cc. water.

Mercuric Chloride: Saturated.

Determination of Sulphur (gravimetric method)

Mix thoroughly 1 gram of the finely ground pigment with 8 grams of sodium carbonate and from 0.5 to 0.7 gram of sodium nitrate, in a large platinum

crucible. Heat carefully over a Bunsen burner or blast-lamp until the mass appears perfectly liquid and in a state of quiet fusion. Run the fused mass well up on the sides of the crucible and plunge the crucible half way into cold water. When cold, treat in a tall narrow beaker with boiling water until all soluble salts are dissolved, and no hard lumps remain. If the solution is colored blue or green by $Na_2Mn_2O_8$, add a few drops of alcohol. The solution will now be colorless, or yellow if chromium is present. Allow the undissolved matter to settle and decant the solution through a filter into a small beaker. Wash the residue with hot water once by decantation and then pour it upon the filter and wash four or five times. Add hydrochloric acid to the filtrate until just acid, evaporate to dryness and heat one hour longer at 110 deg. C. Moisten the residue with hydrochloric acid and set on the hot plate for a few minutes, add 50 cc. water, heat till all soluble salts are dissolved, filter and wash until the filtrate measures 85 or 90 cc. (If the silica in the ore is low, evaporation to dryness is unnecessary. Simply acidify and filter.) Heat this latter to boiling and add 10 cc. of a 10 per cent solution of barium chloride, previously diluted to 30 cc. and brought to boiling point. Allow to stand for some hours, filter, wash with hot water, ignite and weigh as barium sulphate. This weight multiplied by 0.13732 and the product divided by the weight of the sample gives the per cent of sulphur in the pigment.

Specific Gravity

Employ a 50 cc. pycnometer. Insert an accurately weighed portion of sample, fill half full with water, boil gently to remove any air, cool under the tap to room temperature. Fill to the mark with fresh distilled water; after noting the temperature, weigh. Call this weight *C*. Empty flask, clean and refill with distilled water to the mark. The temperature of this test should be identical to the first procedure. Again weigh and call this weight *P*. Let *W* equal weight of dry sample.

Computation: Sp. Gr. $= \dfrac{W}{P + W - C}$

Note: More finely divided pigments which have a tendency to form a film on the water seem to work better when some other liquid, lighter than water is used. Kerosene gives excellent results.)

Computation: Sp. Gr. $= \dfrac{W \times G}{P + W - C}$ where *G* equals the Sp. Gr. of the liquid used.

Determination of Chromium Oxide[1]

Solutions: Sodium thiosulphate—tenth normal—24.82 grams per liter ($Na_2S_2O_3 . 5\ H_8O$).

Potassium hydrogen sulphate—136 grams per liter ($KHSO_4$) (approx. normal).

Sulphuric acid—one part acid—one part water.

Starch solution—Make 2 grams soluble starch into a thin paste with cold water. Pour into 200 cc. boiling water.

[1]See Scott's Standard Methods of Analysis.

Standard permanganate—about 4 grams per liter. Same as used for iron. *Determination:* Heat gently 0.3 gram sample with about 3 grams sodium peroxide (Na_2O_2) in a covered porcelain or Vitreosil crucible.[2] The crucible furnace should be just below redness. Heat for 15 minutes after fusion is liquid.

Cool and place crucible in 400 cc. beaker. Dissolve melt in about 100 cc. cold water, adding some hot water to hasten solution. Boil 10 minutes. If $Fe(OH)_3$ separates out in appreciable quantity it must be filtered off. See Scott's Standard Methods of Analysis. Make nearly acid (litmus) with sulphuric acid. (The solution darkens.) Then add 15-20 cc. $KHSO_4$ sol. and boil for 10 minutes longer.

Cool under the tap. Make up to mark in a 250 cc. volumetric flask. Pipette 50 cc. aliquot into a 300 cc. Erlenmeyer flask. Add about 25 cc. sulphuric acid. Dilute to about 200 cc. with cold water. Add about 2 grams potassium Iodide (KI) and after a few minutes titrate with the thiosulphate solution. When the green color begins to predominate, add a few cc. starch solution and finish titration drop by drop until the blue color fades to pale green.

$$\text{Then per cent } Cr_2O_3 = \frac{\text{cc. } Na_2S_2O_2 \text{ x value 1 cc. x 500}}{0.3}$$

Standardization with Standard Permanganate

Pipette 20 cc. $KMnO_4$ into 300 cc. Erlenmeyer flask. Acidify with 20 cc. H_2SO_4. Dilute. Add about 2 grams potassium iodide and, after a few minutes, titrate with standard thiosulphate, arriving at end-point exactly as described in method.

Reactions: (a) $2\ CrO_3$ plus $6\ KI = Cr_2O_3$ plus $3K_2O$ plus $6I$.
(b) I_2 plus $2Na_2S_2O_3 = 2\ NaI$ plus $Na_2S_4O_6$.

Calculations:

$$\text{Normality of permanganate sol.} = \frac{\text{wt. Fe equiv. to 1 cc. } KMnO_4}{0.056}$$

$$\text{Normality of thiosulphate sol.} = \frac{\text{cc. } KMnO_4 \text{ x 20 x normality } KMnO_4}{\text{cc. } Na_2S_2O_3}$$

Fe_2O_3 x 0.6994 = Fe; then 1 cc. N. $Na_2S_2O_3.5\ H_2O$ should
= .056 Gr. Fe = .01733 grams Cr.
therefore: 1 cc. thiosulphate sol. = 0.0253 grams Cr_2O_3 x norm.

Determination of Cobalt

The cobalt is determined after the removal of the lead manganese (iron and zinc) by precipitating with ammonia and ammonium sulphide as cobaltous sulphide; dissolving this precipitate in nitric acid, adding H_2SO_4 taking down nearly to dryness, then diluting with water, making almost neutral with ammonia, and precipitating with a boiling hot concentrated solution of ammonium hydrogen phosphate.

The precipitate is washed, dried and weighed as $CoNH_4PO_4$.

[2]Weight of sample may be varied.

DISCUSSION

BY M. R. RUST*

Introduction—Dust coats are productive of unsatisfactory results and are only a method for the cheap installation of color with resultant inferior wearing surfaces. There are no happy mediums—a job, on completion, is either good or else no good. Dust coats must definitely result in the latter. It is practically impossible to obtain a floor, dust coated, which will be uniform in either color or the mix of the dusting materials. Furthermore, it is well-nigh impossible to find a floor, prior to dusting, which would have a uniform degree of moisture to hydrate the cement uniformly in the dust mix. Even in the hands of skilled workmen, dust coats will be found satisfactory on only a small portion of their work.

General requirements for pigments—Synthetic and natural pigments are satisfactory, according to the heading, if they meet the qualifications enumerated—and the 4th qualification set forth is "fast to intense sunlight." I have yet to find my first natural color which will meet this requirement, in fact, I might add that I have yet to find one which will closely approach such performance.

It seems a hardship on the contractor to determine whether he is adding only enough natural color to make sure that he does not produce a finish subject to wear. On the same subject, who desires a dull colored concrete surface? The object of using color is to avoid dull monotony and obtain rich decorative beauty. I have encountered comparatively few requests for dull colors and as a manufacturer, we eliminate any thought of such a result from all literature and recommendations. Even the layman appreciates that if it is possible permanently to color concrete to rich intense tones, it is logically possible to produce a dull effect. To criticise the endorsement of natural colors for dull color effects, further, I wish to point out that if a job were completed with the desired dull effect, using a natural color, it would within a few weeks fade to a most unsatisfactory effect.†

*Member Committee 408.

†Without presuming to "take sides" as between synthetic and natural pigment admixtures, may the Editor interpose as a mere suggestion that dull (*un*brilliant) tones are not infrequently desirable in garden landscapes where concrete may be called upon to play a part in naturalistic effects in which brilliant tones would "scream" at nature.—EDITOR

Selection of pigments—I definitely oppose the endorsement of natural colors wherever listed under this heading. As regards the last color, blue, I must confess myself straddling the fence for the good reason that I cannot deny the more stable qualities of Cobalt compared with Ultra-marine—but on the other hand, I fail to see why Ultra-marine is not the more logical choice. Cobalt is unquestionably expensive—almost prohibitive in its pure form whereas Ultra-marines, of the finest preparation, are reasonable and for all practical purposes, will answer most satisfactorily. Despite opinion to the contrary, our experience has been without fault in the sale of such a blue. Admittedly, there are Ultra-marines of most questionable quality and some determination might be made between desirable and undesirable Ultra-marines. It seems that again we come to the same question for debate and that is whether to endorse something for the general good of the industry or to make our recommendations, in the final analysis, for the select few. My suggestion is to favor the multitude.

Methods of test—Nine pounds of pure synthetic color are ample to produce a rich and intensely colored concrete surface. Additional is only waste. Unquestionably nine pounds is more favorable to strong concrete than twelve and the only excuse for permitting the use of twelve pounds is to allow for the use of natural colors—on which I have already commented.

I am confident that our best recommendaton on the use of black is to stand entirely behind synthetic black oxide of iron. I have, personally, conducted a good many experiments to produce a black with more intensity but invariably something is lost with each gain. Not only is the mixing of the color with the concrete extremely difficult but other blacks or blends seem to produce a retarding action which would be highly objectionable and disconcerting to the unknowing contractor.

If we are to assume it true that the color present in a mix tends to dry up the mix and require more water, my suggestion of not more than nine pounds of color per sack of cement is preferable.

Blending pigments—To endorse the contractor's blending of colors is to invite more worry and grief than I care for. The contractor with a huge organization might be interested in

blending—but it is doubtful if he would care to spend the time when he can purchase the exact tone, required, from the manufacturer. Furthermore, presume that he is later required to build some addition to the original job—who possesses the formula for the blend? Here again, we are leaving ourselves wide open. It will probably be best to leave the business of blending to the maker of color with the facilities and knowledge required in blending.

Mixing pigments—Factory prepared colored cement is an excellent product in theory but it has many limitations. For the contractor to use colored cement, he must be prepared either to pay a considerably increased cost for the colored portion of the job or to anticipate less efficiency and color value in his completed work than he would receive through the purchase of the color and intelligent use on the job. Someone must pay the traffic for the machining of the color and the cement, not to mention a few other expenses involved.

Thickness of colored topping—I am again straddling the fence on this subject. I find that the bulk of the work is done with ½ in. topping and while I feel that added thickness is undoubtedly an advantage, we might wisely consider that with each ¼ in. added to thickness of the topping, the color cost is increased by a sizable sum. We may follow a rather common practice of endorsing a definite thickness with the expectation that we are to receive at least 50 per cent of that on completion—but on the other hand, contractors of the Jerry Builder type are hardly likely to follow even that reduction. If we specify ¾ in. and they are accustomed to laying ¼ in.—I strongly believe they will continue to lay just ¼ in. My thought is this, that if we can safely specify the use of ½-in. topping for, say two course monolithic work and ¾ in. for set slab construction, we might do better to adopt such thicknesses.

I am strongly inclined to believe that in attempting to recomment the sand, we are perhaps only adding confusion for the contractor. If nine pounds of synthetic color are used per sack of cement, and the sand is of a grading which will produce good, strong concrete, the finished color will be satisfactory and the slight variation of local sands would produce but very little

difference in the result. Simplicity, to me, is highly desirable in connection with endorsements to be made, widespread, to the contracting fraternity and I am confident that elimination of all trifles or incidentals will aid in getting what we, after all, desire most and that is something bordering on intelligent use of color in concrete.

Surface treatments—My experience with muriatic acid as a cleansing agent has been most unsatisfactory and I should, at no time, care to recommend it other than as an extreme measure. I am most doubtful of it being used successfully by a contractor without etching the finish and such a finish is hardly an attractive one to examine. We do not feel too kindly toward the use of steel wool as it tends to dull the finish but we do strongly favor the finish being rubbed with the mixture of about one-half paraffin oil and one-half naphtha. I agree that we should include after-treatments but I feel that acids should be recommended with restrictions.

I am entirely confident that whatever form our recommendations take in their final stages, we should make every effort to eliminate all trivial matters pertaining to the use of color and seek maximum efficiency in simplicity. I am confident that the bulk of the color used in concrete will be used by the smaller contractor and for this reason, I feel it wise to direct our efforts toward him. For every large colored job, there will be countless small ones and the small jobs will greatly govern the continued patronage of the public in colored concrete.

It would seem that much of the success of colored concrete must revert to some extent to the manufacturer of the color. If he, selfishly, sells an inferior color for the sole purpose of making a sale, he is, indirectly, destroying his own market.

Publishing standard methods of testing or determining colors will make an interesting file for a very limited few but just where shall we find the contractor who will utilize such information? Would it not be better for the Institute to adopt standards and issue these standards to the various color makers with the request that they brand their product, viz.: "This color conforms fully with the standards of the American Concrete Institute for purity and composition?" The manufacturer who would wilfully

misbrand a product would leave himself open to redress on the part of the public.

Uniformity seems a desirable feature in connection with color. We adopted the first step toward simplicity, almost three years ago, by recommending the use of nine pounds of our color per sack of cement—regardless of which of the 12 standards we manufacture. We later pioneered another step by packing all colors in sacks, each containing nine pounds, with the sole recommendation to use one sack of color for each sack of cement used in the topping. Other manufacturers might wisely follow this policy to the ultimate benefit of the industry and more particularly to the benefit of the smaller contractor—who, for some time to come, appears to be our largest and most important factor to consider. He is the man who will make or break colored concrete and while he may be partly lacking in appreciation of architecture, he is our one important objective.

CONVENTION DISCUSSION

AUSTIN CRABBS—Mr. Allan dwelt on the importance of getting just the right amount of color in each batch. It might be interesting, in that connection, to know that one color manufacturer is prepared this year, on request, to furnish color in individual packages having the right amount of color to use in one sack of cement.

MR. ALLAN—That indicates an excellent tendency; several manufacturers are doing that now. But suppose the company sends a package to you and a like package to somebody in the northern part of Iowa, and both of you use it; you will get different colors. You take the one pound package of color and use it with your local cement and develop colors that are practically the same within very, very narrow limits, from time to time, but they will be different colors from those in other parts of the state.

MR. CRABBS—Perhaps I did not make myself quite clear. One color may be seven pounds to the package, another 10 pounds—furnished this way only upon request. He will not furnish those individual packages unless you tell him what your proportions are, how much cement you are going to use and how much fine

aggregate and how much coarse aggregate, and I think that is helping the contractor considerably.

CHAIRMAN COLLINS—In other words, it would enable you or the other manufacturer that Mr. Allan spoke about in the northern part of the state, always to have the same color, although his might differ from yours.

JOHN W. LOWELL—We have given a good deal of study to color in concrete, and one of the most baffling problems is the machinery for mixing cement and color. I was going to ask Mr. Allan if, in their investigations, they have developed any information along that line?

MR. ALLAN—Nothing beyond what you already know, recommending that the color be mixed for a minimum of ten minutes in a regular color mixer, not a ball mill, and we suggest that a small amount of that material be troweled to see if there are any streaks under a steel trowel. That would determine how much more than ten minutes is required. I think a definite effort is made not to reduce the fineness of the material, that is not to grind it as we have sometimes done in the ball mill, but thoroughly mix it in small paddle mills.

NORMAN M. STINEMAN—I believe the members would be interested in a series of articles published in *Concrete* in August, 1928, May, June, November and December, 1930 and January of this year. While these articles cover the manufacture of colors, the author, E. T. Ellis, gives at the end of each article the formula for different shades. For instance, these six articles cover yellows, reds, blacks, greens, blues and browns, and at the end of each article he gives the formula in the form of so many pounds of cement and so many pounds of different colors for a light shade of that particular color, or for a medium or a dark shade.

A. L. ASHER—In Mr. Allan's report there are two very important points—first and most important of all is the classification of mineral pigments. There are few people who know anything about the classification of mineral pigments. I feel that the manufacturer of each pigment should state on his container exactly what the material is, whether it is a chemically pure oxide, a

commercial oxide, reduced color, or natural pigment. That is one thing that I think should be absolutely standardized. The next point is the matter of mixing, inasmuch as the only mineral pigments we can use are those which are insoluble in water. The problem is to get a uniform distribution of color throughout the mortar. I think that the logical thing is to have the color ground with the cement. Even with a ball mill, I feel that the additional fineness you get there will be of no disadvantage at all, and you do get an almost perfect distribution of color throughout the cement, which means uniformity in the cement paste. When the color is brought on the job it must be measured. You cannot measure a material uniformly that runs 90 to 98 per cent through a 325 mesh. If the contractor knew that four bags of a colored cement would lay a hundred square feet of floor one inch thick, it would eliminate a lot of his troubles in figuring his costs and doing the work on the job.

H. F. Hedderick—Mr. Allan recommended a blade type color mixer. Several months ago we were interested in trying to find a color mixer and the Portland Cement Association recommended the pebble mill type. We were able to find those without much trouble, but their cost is extremely high. We tried to find a machine of the blade type, made especially for mixing colors. The only one we could find took half a bag to a bag of cement at the time, not large enough for our work. I wonder if the machines Mr. Allan recommends are on the market in the size to take five or six bags?

Mr. Allan—For such quantities you would have to use a regular stucco mixer. We were figuring on one sack batches and I think the regular stucco mixers would be best for the large batches you mention.

Nolan Browne—I should like to call attention to the use, in color work, of mineral pigments with an integral accelerator and hardener. We find that the advantage is threefold; first, their use accelerates the mixture and necessitates that the mechanic get off the job a lot quicker, thereby getting more work done; secondly, a thinner coat will wear the same length of time as a thicker coat, due to the hardening effect; and third, it reduces efflorescence on account of the waterproofing quality of

the admixture. There is a small amount of efflorescence when the material is first cured because the water does bring a certain amount of salt to the surface during the setting-up process; but when once cleaned, it has been our experience that efflorescence does not reappear; whereas, without a waterproofer, dampness is present and efflorescence may recur time and time again. I think it would be a good thing for the committee to give some consideration to this. In our own experience we have reduced the slump on the colored product to one and a half inches. Now that does make a very hard mixture to handle unless the mechanics are quite familiar with it, but it surely does get the results.

A MEMBER—I'd like to ask a question about blue color. Several years ago we used an ultramarine blue and applied it as a face on roofing tile. We used about ten pounds of color to a bag of cement; cured it in a steam room for about a week and put it on the roof and in about three months the blue color had faded entirely into a gray white. We took that roof off and made a mix of about ten pounds of blue color to the bag of cement and made a creamy mixture and blew it on the tile with a gun, about $\frac{1}{16}$ to $\frac{1}{8}$ in. thick. We put that tile back on the roof, and the roofing tile is a rich blue color. I would like to know why the color failed in the first instance and why it stood up when blown on with the gun.

MR. LOWELL—Are you sure that the tile color had not faded by the time you took it out of the curing room?

A MEMBER—No, it did not fade until we got it on the roof.

MR. LOWELL—I know that blue will fade under sufficiently high temperature.

ROY L. PECK—I'd like to ask Mr. Allan if he has any recommendation to make as to the use of color in surfaces of outdoor swimming pools to eliminate the use of color throughout the wall?

MR. ALLAN—We have limited this report to troweled surfaces.

MR. ASHER—The gentleman asked a question as to fading of ultramarine blue. There are two definite ultramarine blues. One is ultramarine blue that is absolutely a reliable blue and made for the concrete industry. The other ultramarine blue is

made for the paint industry. My conclusion is he was using a commercial ultramarine blue and got an excessive action of alkali. Using it with the gun after the concrete had hardened, he did not get that excessive action of alkali.

BENJAMIN WILK—It seems to me that much would depend on the fact that, mixing it integrally the particles were not coated as thoroughly as in the thick surface application. In our experience, with a lean mixture and about six pounds of color to the sack of cement, we found that the trouble was in the color washing off the surface of the aggregate. There was not enough thickness of the color.

MR. ASHER—Well, the color in both cases was applied to the facing; we used the same amount of color in each instance.

Readers are referred to the JOURNAL *for October, 1931 (Vol. 28) for further discussion which may develop. Such discussion should reach the Secretary by Sept. 1, 1931.*

Proposed Recommended Practice for the Manufacture of Concrete Building Block and Tile

*Report of Committee 708**

P. M. WOODWORTH, AUTHOR-CHAIRMAN

FOREWORD

These recommendations are intended to aid manufacturers of concrete building block and tile to make products that meet standard specifications of the American Concrete Institute[1] and to produce them economically. In addition to recent developments in the manufacturing procedure and in the use of porous aggregates, considerable attention is given to plant layout. This recommended practice is intended particularly for plants with an average daily production of 500 or more units. Much of the material will be of value for smaller plants.

A. PLANT LAYOUT

1. General Considerations

The economical production of concrete masonry units starts with the design of the plant which should be based on the probable volume of sales that will be developed during the succeeding three to four years. The plant layout should be such that new producing units can be added as the volume of sales makes it imperative without rearranging or disrupting the initial layout. Most manufacturers of concrete products machinery have plant layouts which are well adapted to their equipment. However, a layout fitted to one particular set of machines may not be entirely

*This report, by Mr. Woodworth, Author-Chairman of the committee has been submitted for preliminary advice and suggestion to the members of the committee: E. W. Dienhart, C. J. Herzog, M. I. McCarty, Eugene F. Olsen, W. P. Stanton and Stanton Walker and presented at the 27th Annual Convention, Milwaukee, Feb. 24-26, 1931, for discussion. It is published with convention discussion (which was all too brief) for further consideration and is open for general discussion scheduled for publication in the JOURNAL for Oct. 1931 (Vol. 28)—available to the Secretary by Sept. 1, 1931.

[1]American Concrete Institute Standard Specification P-1-A-29 is an appendix to this report.

suitable for another, consequently the type of equipment should be selected before the plant layout is definitely settled. There are a number of general considerations regarding plant layout which are common to most types of equipment.

Discussion—In establishing a concrete building block or tile plant a carefully prepared market analysis is the first step. The total volume of sales that will be developed during the next three to four years will determine the size of the plant that should be built. Many manufacturers have definitely precluded any chance of economical manufacture by building plants that are too large and over capitalized. Unwarranted optimism regarding volume of business seems to be the rule in starting a concrete building units plant. An important percentage of the high-fixed-capital plants established during the past five years have not been profitable. This should not be interpreted as meaning that small, poorly equipped plants are profitable but that to be profitable the size of the plant should be in proportion to the business that will be developed with an aggressive sales organization.

2. Elevation, Grading and Drainage

Raw materials and finished products should be handled by gravity wherever possible. The elevation of the plant floor should be sufficient to provide drainage away from the plant in all directions and a slope of about one-eighth in. per foot away from the machine to the end of the runways.

Discussion—In general the block or tile machine is at the highest point on the plant floor to provide sufficient slope from the machine through the curing rooms and out to the far end of the yard whether industrial cars, lift truck or gravity conveyors are used. The yard should be graded slightly below the concrete runways or the level of the industrial tracks because the yard tends to fill up with loose pieces of concrete, sand, gravel, etc. causing pebbles to collect on the runways, making operation of cars or trucks difficult.

In laying out a products plant, grade stakes for the yard, curing room and main factory floor should be carefully set first. Frequently a few loads of material used to build up the elevation to the proper grade in the beginning will save a manufacturer a great deal of trouble and expense a year or so after the plant is in operation.

3. Conveying Equipment

The use of conveying equipment other than that ordinarily provided with the machine is advisable if the labor saved more than offsets the interest on and depreciation of the additional equipment. Whether or not lift trucks, industrial cars, elevators, belt or roller conveyors, batch cars or other conveying equipment should be installed depends on the amount of reduction in the cost of manufacture obtained with this equipment.

4. Arrangement of Equipment

The more compact the arrangement of the plant and still provide for freedom of movement of men and equipment, the lower the labor cost. Aggregate storage and cement supply should be placed as near mixers as possible.

Discussion—The tendency to limit the amount of space at the side and in front of machines so that lift trucks or cars cannot be manipulated easily to and from the machines should be avoided. While it is important to save all possible extra steps, these should not be saved at the expense of cramping the movement of material through the plant.

Provision for ample skylights and artificial illumination is important. Painting the inside of the plant a light color is desirable.

5. Cement Handling

Cement storage facilities should be provided to keep the cement dry whether it is handled in bulk or in sacks. Bulk cement, due to the tendency to "fluff," should be measured by weight.

6. Aggregate Proportioning Equipment

Accurate equipment for proportioning aggregate either by weight or by volume is essential. Such devices should work quickly and easily. Overhead bins with the other necessary equipment for handling will usually prove economical for plants regularly producing 500 or more units daily.

Discussion—Several efficient weight batching devices are on the market and are to be recommended over volume measurements. No corrections have to be made for bulking of materials due to moisture. The only correction necessary is for the variations in moisture content in different shipments of aggregate.

7. Curing Room Construction

After units are molded, the quicker they are placed in favorable curing conditions the better the quality of the concrete. Curing rooms must be relatively tight to prevent air currents and loss of heat. They should have insulated roofs. The rooms are usually made wide enough to accommodate 2 racks, allowing 6 inches between radiation and the rack on each side and 10 to 12 inches in the middle. Tight enclosures should be used at both ends of the tunnel. The enclosures may be either moving doors made of well painted wood or light weight metal. Tight fitting canvas curtains are sometimes used on the plant end of

the rooms. Usually the doors are hinged at the top or slide in vertical guides which are made tight to prevent loss of heat and moisture. Curing rooms should be painted white on the inside to aid visibility.

Discussion—The tendency has been to build curing rooms too high. A temperature of 125 to 135 deg. F. is common against the roof, while at the floor it is not more than 70 to 75 deg. F. The heat should be kept down as low as possible and building the room no higher than is absolutely necessary to clear the top row of block is desirable. This will require workmen to stoop slightly while moving products into and out of the rooms but is no hardship.

If the layout of the plant makes it necessary to build the tunnels longer than can be filled in a half day's run, dividing curtains, usually of canvas, should be provided in the tunnel so that a run of 3 to 4 hours can be enclosed and curing started. This arrangement requires dividing the curing equipment so that each section can be regulated independently. In determining the length of curing tunnels, a minimum of 6 in. should be allowed between the ends of racks. The space between the radiation and the racks and between the racks in the center is to facilitate the movement of racks and the circulation of heat and moisture in the rooms.

8. *Types of Curing Systems*

There are six common methods used to provide satisfactory curing conditions for the freshly molded units. Refer to Figs. 1, 1A and 2.

Type "A" provides radiation and steam moisture control independent of each other. A header is placed within 6 in. of the

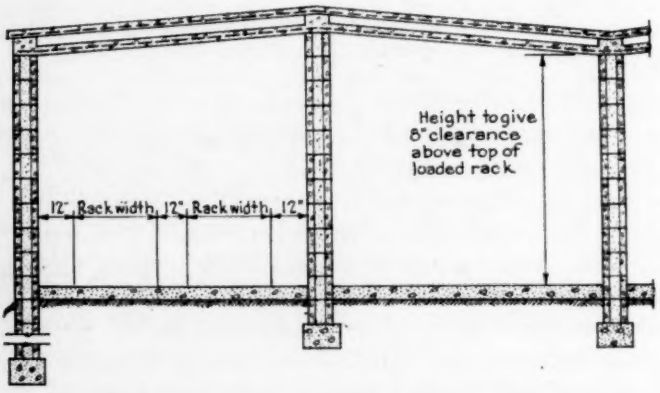

FIG. 1—TYPICAL LOW PRESSURE STEAM CURING ROOM

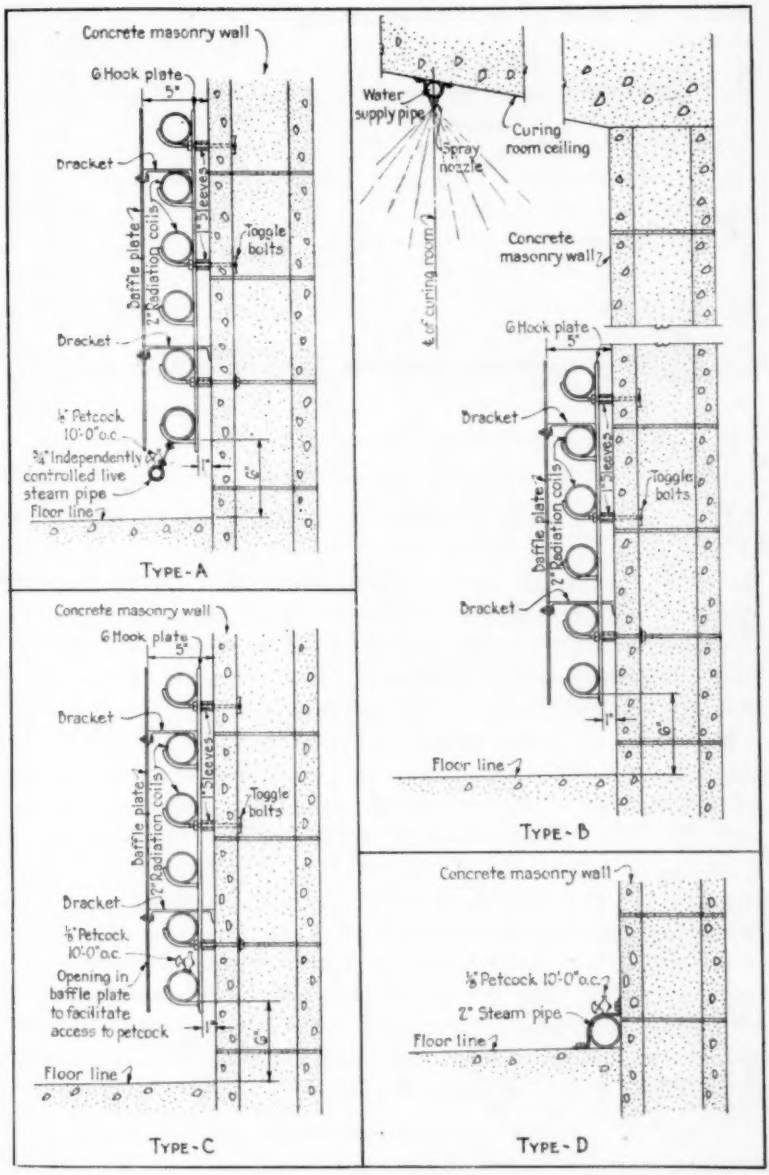

FIG. 1A—PRINCIPAL TYPES OF LOW PRESSURE STEAM CURING INSTALLATIONS

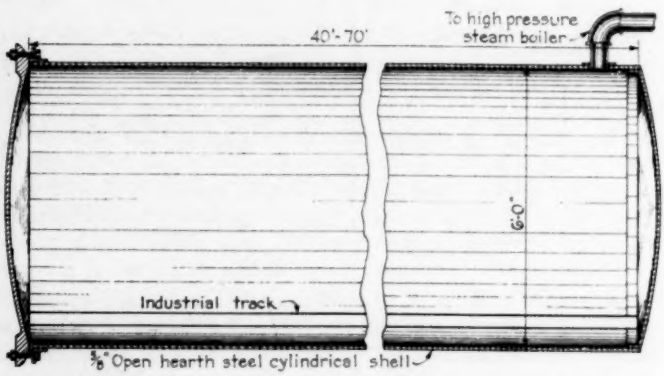

FIG. 2—HIGH PRESSURE STEAM CURING CYLINDER

floor at both ends and on both sides of the curing tunnel. Two-in. pipe connects these headers. Usually six pipes are required on each side in the northern sections of the United States if masonry walls and insulated roofs are used and if the rooms are of 2-rack width. The headers should be provided with three or four extra plugs so that additional radiation can be tapped in if the temperatures obtained are not high enough. The moisture is provided by steam through a ¾-in. pipe running just below the bottom pipe of the radiation system. This pipe is fitted with ⅛-in. petcocks on 10 foot centers staggered with those on the opposite wall. The petcocks should be directed upwards and at a slight angle toward the wall so that the steam is forced up through the radiation coils. Radiation and moisture are controlled by separate valves outside of the room. Cement-asbestos or galvanized iron baffle sheets are suspended 2 in. in front of the radiation coils. The bottom of the baffle sheet is placed even with the bottom pipe of the radiation. This acts as a jacket and causes a circulation of heat and moisture in the tunnel and prevents block directly opposite the pipes from becoming dry.

Type "B" provides independent steam coil radiation with moisture supplied through fog nozzles attached to the ceiling of the room. These fog nozzles are operated at water pressures of 30 pounds or more per square inch. If connected with the

regular water system, a heating coil should be provided so that the fog is of a temperature of at least 100 deg. F. when it enters the room. Baffle plates should be used in front of the radiation coil the same as is described for Type "A."

Type "C" provides radiation and steam moisture combined. The construction is the same as in Type "A," except that the bottom return pipe on the radiation coil is fitted with ⅛-in. petcocks on 10-ft. centers staggered with those on the opposite wall.

Type "D" provides for heat and moisture by exhausting live steam into the room through a single pipe placed within 6 in. of the floor on both sides of the room. This pipe is either drilled with ⅛-in. holes or fitted with ⅛-in. petcocks.

Type "E" provides for the curing of products in cylinders where the pressures vary from 100 to 125 lb. per sq. in. Special equipment is required similar to that used in the manufacture of sand-lime brick. While this method is not common at present, it seems to have good possibilities.

Type "F" is the least that can be expected in the way of curing equipment. It provides for rooms or sheds that are reasonably tight to prevent excessive air currents. They are equipped with fog nozzles to provide moisture. Usually this system is used where temperatures do not fall below freezing.

Discussion—Of the first four methods described, Type "A" seems to be best, because it enables the manufacturer to control independently the heat and moisture. In freezing weather or where it is necessary to get units on the job in a relatively dry condition, the mositure can be shut off after a period of moist curing and the products dried considerably by radiation. Type "A" also has the advantage of giving more thorough circulation of heat and moisture, thus tending to even the temperature and moisture conditions in the top and bottom of the curing room.

Type "B" is nearly as satisfactory as Type "A" but is slightly deficient in obtaining circulation in the curing room.

Type "C" provides ample radiation and moisture content. The drawback to this method is that the heat and moisture are controlled together. With this system it is nearly impossible to provide just heat, which is necessary sometimes for drying units after the moist curing.

Type "D," while commonly used, is not nearly so satisfactory because in order to get sufficient heat in the tunnel it is necessary to exhaust too large an amount of steam into it. Such an excess nearly always results in moisture

getting into the manufacturing part of the plant, causing unhealthy working conditions and deterioration of equipment, buildings and cement.

Type "E" should be thoroughly investigated by products manufacturers designing new plants because present indications are that the units can be cured in from 8 to 12 hours and have a strength at least equivalent to the 28-day strength under normal curing conditions. In addition, the units seem to be quite thoroughly dry and ready for immediate delivery when they come from the pressure cylinders. This makes for prompt delivery and reduces stock piles.

9. Summary of Plant Layout

Discussion—Fig. 3 shows a conventional layout embodying many of the above suggestions. In this plan the overhead bin (1) may be filled by any type of elevating equipment. The advice of the machinery manufacturer will be valuable in deciding on the type of elevating equipment to be used. The size of the bin is determined by the capacity of the plant and the regularity with which the material can be obtained. Generally not less than a three days' supply should be provided for. Opening (2) should be fitted with a measuring device, preferably weighing equipment for proportioning materials. A chute, weighing lorry or dump car (4) may be used for carrying aggregate to mixer.

The stock of cement should be piled on platform (3) close to mixer. Water tank (5) should be placed above mixer and out of the way of charging equipment. It should be provided with an automatic valve and water gauge for filling and with a perforated pipe for discharging. Space (6) under platform may be used for storing pallets, extra equipment, also a portion may be used for boiler room.

Mixer (7) on the raised platform discharges directly into agitating feeder from which concrete is elevated from machine hopper by conveyor (8). It is generally more satisfactory to have one mixer for each machine. (9)

A modification of the layout at this point is in common use. The overhead storage is elevated sufficiently so that the measuring equipment and mixer can be placed on a platform high enough to discharge directly into the hopper of the machine. Which of these two methods is better depends on the cost under local conditions. The cost of providing the extra height of storage space and elevating equipment should be measured against the cost of the agitating feeder and machine elevator. There is also a loss of floor space and more equipment to be cleaned in the first arrangement.

Concrete floor and yard runways slope from front of machine to far end of storage yard, usually ⅛ of an inch to the foot. Lift trucks (10), industrial cars or conveyors carry units to the curing room. Inside doorway (11) should be closed with vertically hinged or sliding doors or canvas curtains. Moisture in curing room is supplied as described under Section 8, "Types of Curing Systems" through coil (12) or by spray nozzles (13). Allow at least 6 in. between ends of racks (14). Outside doorway (15) should be closed with vertical hinged or sliding doors. Concrete runways (16) should be at least 1 in. above yard level and 18 in. wider than the racks or cars. Sufficient turn-

ing radius for the cars at runway intersections should be provided. For ordinary equipment sufficient turning radius is provided by placing at each corner of intersection a triangular section of paving extending 6 ft., back from the corner in both directions. This may seem like a small point in making the original layout but it is very important and unless it is provided for will lead to endless difficulty and waste of time later.

B. MATERIALS

10. Cement

Cement should meet the requirements of the current standard specifications for portland cement of the American Society for Testing Materials. It should be stored where it is completely protected against moisture.

11. Aggregates—General Requirements

Aggregates should consist of sand, pebbles, crushed stone, slag, burned shale, cinders or other approved inert materials or combinations thereof. Dense aggregates, such as sand, pebbles, crushed stone, crushed slag should be sound and durable and free from excessive amounts of dust, soft or flaky particles or shale or other deleterious materials.

Porous aggregates, either natural or manufactured should be free from injurious amounts of acid or alkali or compounds forming acids or alkalis, industrial wastes and, in the case of cinders, combustible matter in excess of 35 per cent of the weight of the aggregate. They should be of such strength as to produce units meeting the A. C. I. specifications. All aggregates should be free from frost or lumps of frozen material. Where stationary aggregate bins are provided, a coil of steam pipe should be arranged around the outlet of the bin so that the aggregates can be heated to remove frost and frozen lumps. Such heating will aid in the early hardening of concrete in cold weather. The use of crusher-run or bank-run material where the proportion of fine to coarse varies is usually unsatisfactory. The aggregates should be screened into fine and coarse particles and stored in separate bins.

12. Fine Aggregate

Fine aggregate should be considered as material passing a screen with four meshes per linear inch. It should have at least 15 per cent retained on a No. 8 screen.

13. Coarse Aggregate

Coarse aggregate should be considered as material retained on a screen having four meshes per linear inch. Maximum size of coarse aggregate should not exceed one-third the thickness of the thinnest web of the units to be manufactured.

Discussion—Storage bins should be designed to minimize segregation of aggregates. This segregation is limited to some extent by separating the materials into fine and coarse.

14. Water

Mixing water should be free from injurious amounts of oils, acids, organic material or other harmful matter. Water fit to drink is usually satisfactory.

15. Proportions

In the selection and combination of fine and coarse aggregate and in the proportioning of total aggregate to cement, the manufacturer has control to a large extent over the properties of the resulting concrete.

Discussion—The combination of fine and coarse aggregates which will develop the maximum strength may lead to units that have too rough a texture and edges that are too uneven to make the product saleable. The grading that might result in the maximum fire resistance might not be best for maximum strength or minimum absorption. For this reason, the combination of aggregates and the proportion of aggregate to cement are usually a compromise which will produce to the highest degree all of the desirable characteristics in the finished product.

16. Strength

The aggregate and the cement should be proportioned in such a way that the finished units will meet the American Concrete Institute Specifications or local building code requirements when made under local plant conditions. The only reliable way that the Committee knows for establishing definitely the proper proportions of fine to coarse aggregate and total aggregate to cement to obtain the required strength is through strength tests made in a properly equipped testing laboratory. These tests should be run frequently before the plant gets into regular commercial production and after that only often enough for checking.

In general, the coarser the grading of the aggregate, the greater the strength of the unit for any given cement content, provided there are sufficient fines in the aggregate to make the mix work-

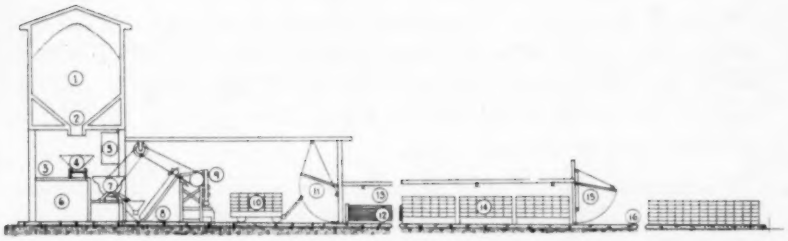

FIG. 3—TYPICAL DIAGRAMMATIC LAYOUT OF PRODUCTS PLANT

able with the given type of molding equipment. However, the grading must not be too coarse or there will be breakage in handling the units from the machine and the surfaces and edges may be too rough and irregular for a saleable product.

With the fine aggregate all passing a No. 4 sieve and the coarse aggregate graded from ¼ to ⅜ in., the maximum proportion of coarse material that can be used to advantage is about 50 per cent of the total aggregate used in the mix. Generally not more than 40 per cent of coarse material gives the desired combination and in very few instances will only 25 per cent of coarse aggregate produce a unit which has the greatest strength for a given amount of cement. The proportions of cement to be used for any given combination of fine and coarse aggregates can only be determined by trial. Trial mixes containing 25, 35, 45 and 55 per cent of coarse aggregate graded from No. 4 to ⅜ in., mixed with the fine aggregate should be made with different proportions of cement to total aggregate 1:6, 1:7, 1:8, 1:9, 1:10 and 1:11 by damp loose volume of mixed aggregate.

The first indication of the suitability of aggregate combination and cement-aggregate proportions is determined at the block machine. If the appearance of the surface and edges is satisfactory, and if the block can be handled easily and quickly without broken webs or corners, the mix is suitable with regard to appearance and handling.

After setting aside the first two and last two block from each of these trial mixes, three block from each mix should be selected

and cured according to ordinary plant practice and kept for testing at 28 days by recognized testing laboratory. From this original group of tests the manufacturer can tell within a relatively narrow margin the proportions of aggregate to cement that are necessary to produce the strength required by the A. C. I. specifications or the local code.

Uniformity of grading of aggregates is important. If the aggregate is obtained from well established commercial plants usually little difficulty is encountered. However, if the grading is irregular, it may be necessary for the manufacturer to find a different source of supply or install a set of screens to divide the material into fine and coarse and to eliminate the over-size particles.

A screen analysis of the aggregates finally selected for producing the desired units should be made and checked occasionally to determine that the grading has not varied appreciably. If it does vary adjustments in the fine and coarse aggregate proportions or in the total aggregate proportions to cement will have to be made.

It is well for a manufacturer to aim at from 75 to 100 lb. per sq. in. of gross area more strength than minimum requirements.

Discussion—In washed fine aggregate it frequently happens that too much of the very fine sand is washed away. This is particularly true of the sizes passing a 28-mesh sieve. A close distinction should be made between silt and a fine sand.

In order to obtain proper workability with dense aggregates the fine aggregate should have not less than 3 per cent nor more than 10 per cent of the material passing a 100-mesh sieve, provided the fine aggregate is well graded between the 100-mesh and ¼-in. screens. If the units in the trial batches break easily when being handled from the machine to the rack and from the rack into the curing room, the probability is that the fine aggregate is deficient in fines. A screen analysis should be run. If deficient in fines, the addition of small amounts of fine sand, stone screenings or other finely divided aggregate will aid in making the concrete workable and easily handled.

By following the suggestion above to make trial batches and have tests made the plant can get into operation on a satisfactory basis in a short time. If it is necessary to get in production in less than 28 days, block can be made and cured in the regular way and tested at 7 days. The 7 day strength can be assumed to be about 70 per cent of the 28-day strength. This is only an approximation and should be checked at 28 days.

Fine material generally cuts down the strength of the concrete and results in higher costs. Very fine material should be limited to the bare requirements

to make a block that can be handled away from the machine without cracking or breakage.

Manufacturers who use the Inspection and Certificate Service of the Underwriters' Laboratories[2] have a positive guarantee that their product will meet the A. C. I. specifications. This Service usually eliminates the necessity of further commercial tests.

17. Absorption

In combining the aggregates and in proportioning the total aggregates to cement to obtain units which meet the absorption requirements of the specification, but little difficulty is encountered if the aggregate does not contain too much or too little fines. Generally the mix that gives the maximum strength will tend to give the minimum absorption. If the absorption is too high a study of the aggregates giving particular attention to the fines will generally show what is necessary to make the correction.

18. Surface Texture

The requirements for surface texture will be controlled largely by local market conditions. Rough textures are usually desired for partition units and those that are to receive stucco or plaster. A close texture is desired for exposed ashlar and other exposed units.

Discussion—With regard to surface texture there is a wide variation in what is considered saleable in different markets. For example, in one market a very coarse textured block is acceptable to the architects and contractors even for exposed work, whereas in another market less than 100 miles away a coarse texture will not be permitted in the backing of a faced block. Keeping this in mind, the manufacturer should educate the builders from the beginning to use relatively coarse textured units.

19. Density

With the use of dense aggregates the proportions which will produce the densest products are generally those which contain the maximum amount of coarse aggregate and still contain enough fine aggregate to produce a smooth surface. With porous aggregates used in the production of light weight units, the amount of material in the mix passing a 50-mesh sieve is generally limited and in addition more of the coarse aggregate is used to produce a unit of less density and lower weight. This is generally

[2]Underwriters' Laboratories, 207 East Ohio Street, Chicago, Illinois.

desirable for light weight units except where fire resistance or water tightness are important.

20. Consistency

Concrete units made from dense aggregates on tamp or pressure machines should be mixed as wet as practicable and still prevent appreciable sagging or distortion of units. Generally a slight water web should show on the surface of the unit next to the mold box. With the pressure method a slight excess of moisture should be forced from the unit when the full pressure is applied. When vibration is used to consolidate the material the mix should be as dry as practicable to completely fill the molds and produce a pronounced water web on the surface without slumping or sagging. Where the wet cast method is used the water content should be reduced to a minimum and vibration and spading used to facilitate getting the concrete into the molds without forming aggregate pockets.

With porous aggregates, mixes somewhat drier than those used for dense aggregates are generally recommended for tamp or pressure method as this will produce a fairly coarse texture which is desired for the direct application of plaster or stucco. If porous aggregates are used in the vibration of cast methods, the surface appearance will be nearly the same as when dense aggregates are used.

21. Mixing

In dense aggregate concrete the cement and aggregate should be mixed for one minute or until the mass is uniform in color before the addition of the mixing water. All materials should be mixed from three to six minutes after the addition of the water. The longer mixing time increases the strength, density and workability. The mixer should be of such capacity that the concrete can be mixed for the time recommended without retarding production. Excessively long mixing periods, for example, from 10 to 15 minutes, while somewhat beneficial, are not generally recommended or considered economical. With porous aggregates, due to their relatively high absorption, one-half to two-thirds of the total mixing water required should be mixed with the aggregates for 2 to 3 minutes prior to the addition of the cement. Then the cement and the remaining mixing water should be added and the mixing continued for 2 to 3 minutes.

Discussion—For several years it has been considered that a batch mixer of sufficient size to keep the block making machine running at capacity with one batch every 10 minutes was necessary. The Committee recognizes that thoroughness of the mix and not time of mix is the important consideration. If, through the use of continuous mixers or other mixing methods, concrete of equal or superior strength can be obtained in less time than it has indicated, such methods should be thoroughly satisfactory.

22. Curing

Concrete hardens in the presence of moisture and heat. If moisture is not present the chemical reactions in the cement stop. If the temperature falls below 40 deg. F. these reactions practically stop. Consequently, in the absence of moisture or heat above 40 deg. F. there is little if any hardening of the concrete.

From a manufacturing standpoint it is important that units be made available for market as soon as possible. This requires that special attention be given to providing moisture and heat. The curing room should be provided with equipment that will keep the moisture in the room slightly above the saturation point at any temperatures used. Methods for obtaining this moisture were discussed in section 8.

The higher the temperature of the curing room above 40 deg. F. the more rapidly the concrete hardens, provided there is always a slight excess of moisture in the room. Means of providing artificial heat for curing were discussed in section 8. The units should be put into a curing room and protected against draft immediately after they are molded. If they are to be steam cured, the heat and moisture should be turned on as soon as possible. Proper curing conditions during the first 48 hours after the block are molded are particularly important in producing strength and density.

Discussion—In curing rooms except where high pressure steam is used it is difficult to get the temperatures much above 140 deg. F. because of heat losses. Temperatures in high pressure steam curing vary from 325 to 400 deg. F.

It has been common practice to provide a substantial excess of moisture in curing rooms. This can be eliminated because only a slight excess of moisture is required. The right amount can be determined easily by the appearance of a light fog in the curing runnel when the temperature is at its high point. Adjusting the petcocks to permit the right amount of moisture should be done when the plant is first started and little if any further adjustment will be required.

23. Length of Time of Damp Curing

With artificial heat and moisture provided as discussed in Types A., B, C and D in section 8, 24 hours of curing is considered the minimum. With high pressure steam curing, such information as is available indicates that 12 hours of curing is ample. Where only sprinkling is used the units should be protected from temperatures lower than 50 deg. F. and kept wet for not less than 3 days.

If the units are cured as described, they may be stacked in the yard and kept damp until they develop the strength and absorption requirements of the specification.

24. Dry Curing

Then the sprinkling should stop and the units should be allowed to dry. It is desirable that a covered yard or some other method be provided to keep rain and other precipitation away from the block.

Discussion—It must be recognized that the drying after wet curing is just as much a part of satisfactory manufacturing as mixing, tamping or wet curing. Several recent specifications require that when units are delivered on the job they shall not contain more than 30 to 40 per cent of the amount of moisture they hold when totally saturated. Stacking units close together in large piles prevents them from proper drying and even in the middle of the summer, units a few courses in from the outside of the pile remain damp for several months. For this reason the piles should be made narrower and it has been suggested that the block be stacked in the pile with cells horizontal and opposite so that there will be direct air currents through the pile. Some manufacturers have suggested that raising the lower course of block a few inches off the ground on small sills and then stacking the block with cells vertical and opposite will cause a chimney action to occur which will aid in drying the block. Which of these two methods is better has not been determined but either of them will aid in drying the units.

25. Faced Units

Concrete masonry units with special facing material made from selected aggregates, colored cement or other materials should be made in the following manner: The facing material should be screened to pass a $\frac{1}{8}$ in. screen and all retained on a 100-mesh screen. A mixture of 1 part of cement to $2\frac{1}{2}$ or 3 parts of aggregate will give best results. Mixes richer than these are likely to produce crazing. Mixes leaner are likely to be too absorbent. If special aggregates are used in the facing material,

as soon as the block are molded the surface is treated with a fine water fog spray to remove the surface film of cement and the units are put in the curing room and handled the same as other units.

Appendix

Report of Committee 708, February 1931

Standard Specifications for Concrete Building Block and Concrete Building Tile—(P-1-A-29)

GENERAL

1. The purpose of these specifications is to define the requirements for concrete building block and concrete building tile to be used in construction.

2. The word "concrete" shall be understood to mean portland cement concrete.

3. The average compressive strength of 3 or more concrete block or concrete building tile in lb. per sq. in. of gross cross-sectional area as laid in the wall shall not be less than 700 lb., no one unit falling below 600 lb. 28 days after being manufactured or when shipped.

Wherever concrete block or building tile are used to carry unusual heavy loads, the average compressive strength of 3 or more of these units 28 days after being manufactured or when shipped in lb. per sq. in. of gross cross-sectional area as laid in the wall shall be at least 10 times the figured superimposed load to be applied.

Non-load-bearing concrete block and concrete tile shall have sufficient strength necessary to prevent excessive breakage during delivery and handling.

4. The gross cross-sectional area of a one-piece concrete block or tile shall be considered as the product of the length times the width of the unit as laid in the wall. No allowance shall be made for air spaces in hollow units. The gross cross-sectional area of each unit of a two-piece block or tile shall be considered the product of the length of the unit times one-half the thickness of the wall for which the two-piece block or tile is intended.

5. The compressive strength of the concrete in units of all classifications except "non-load bearing block" shall be at least 1,000 lb. per sq. in., when calculated on the minimum cross-sectional area in bearing.

Absorption Requirements

6. Concrete building block and tile to be exposed to soil or weather in the finished work (without stucco, plaster or other suitable protective covering) shall meet the requirements of the absorption test.

7. All concrete building block and tile not covered by Paragraph 6 need not meet an absorption requirement.

8. Concrete block and tile shall not absorb more than 10 per cent of the dry weight of the unit when tested as hereinafter specified, except when it is made of concrete weighing less than 140 lb. per cu. ft. For block or tile made with concrete weighing less than 140 lb. per cu. ft. the absorption in per cent by weight shall not be more than 10 multiplied by 140 and divided by the unit weight in pounds per cubic foot of the concrete under consideration.

Sampling

9. Specimens for tests shall be representative of the commercial product of the plant.

10. Not less than three and preferably five specimens shall be required for each test.

11. The specimens used in the absorption test may be used for the strength test.

METHODS OF TESTING

Absorption Test

12. The specimens shall be immersed in clean water at approximately 70 deg. F. for a period of 24 hours. They shall then be removed, the surface water wiped off, and the specimens weighed. Specimens shall be dried to a constant weight at a temperature of from 212 deg. to 250 deg. F. and re-weighed. Absorption is the difference in weight divided by the weight of the dry specimens and multiplied by 100.

Weight of Concrete

13. The weight per cubic foot of the concrete in a block or tile is the weight of the unit in pounds, divided by its volume in cubic feet. To obtain the volume of the unit fill a vessel with enough water to immerse the specimen. The greatest accuracy will be obtained with the smallest vessel in which the specimen can be immersed with its length vertical. Mark the level of the water, then immerse the saturated specimen and weigh the vessel. Draw the water down to its original level and weigh the vessel again. The difference between the two weights divided by 62.5 equals the volume of the specimen in cubic feet.

Strength Test.

14. Specimens for the strength test shall be dried to constant weight at a temperature of from 212 deg. to 250 deg. F.

15. The specimens to be tested shall be carefully measured for overall dimensions of length, width and height.

16. Bearing surfaces shall be made plane by capping with plaster of paris or a mixture of ½ portland cement and ½ plaster of paris, which shall be allowed thoroughly to harden (from 3 to 6 hours) before the test. No point on the surface shall deviate from the plane more than 0.003 in. The cap shall not be thicker than ⅛-in. It shall be formed by means of an accurately machined metal plate or a heavy plate glass having a true surface.

17. Specimens shall be accurately centered in the testing machine.

18. The load shall be applied through a spherical bearing block placed on top of the specimen. The rate of loading after 50 per cent of the ultimate load has been applied shall not be greater than that which will produce a shortening of the specimen of 0.02 in. per minute.

19. When testing other than rectangular block or tile care must be taken to see that the load is applied through the center of gravity of the specimen.

20. Machined-steel or cast-iron plates of sufficient thickness to prevent appreciable bending shall be placed between the spherical bearing block and

the specimen. In no case shall the distance between the edge of the spherical bearing block and the end of the bearing plate be greater than twice the thickness of the plate. Where a number of thin plates are used, in no case shall the plates be less than one inch thick nor shall any plate extend beyond the one immediately above it a greater distance than twice the thickness of the plate.

21. The specimen shall be loaded to failure.

22. The compressive strength in pounds per square inch of gross cross-sectional area is the total applied load in pounds divided by the gross cross-sectional area in square inches.

CONVENTION DISCUSSION

W. D. M. ALLAN—I should like to call attention to the importance of the last point Mr. Woodworth made regarding the drying of the units after they have been cured. A unit 28 days old or 90 days old may not be any drier than one three or four days old. Several products manufacturers and others have had an opportunity in the last few weeks to criticize the master specifications of the federal government covering concrete masonry units. That specification requires that a unit shall not have more than 40 per cent of the total saturated weight of moisture when delivered on the job. That means, for instance, that a cinder concrete block with an absorption of 16 per cent when saturated, would be cut down to two-fifths of that—about 6.4 per cent, when delivered on the job. Even in the middle of the year, taking block out of the center of a large stock pile that has been rained on a month before, block will rarely meet that requirement, so we have got to add to our manufacturing processes another step that is as important as anything we have been considering in the past, and that is drying the units after they have been wet-cured. It is as certain as can be that after all the discussion on volume change and this specification covering moisture content when units are delivered, it will be a matter of only six months or a year when many specifications will have a limit of that kind. The tendency is in that direction, and every manufacturer is going to have to recognize it if he is going to get important work.

BENJAMIN WILK—There are just a very few points, I think, to be considered. In view of the fact that this curing condition is so essential, it will be desirable to consider the use of paved yards entirely. We found over a considerable area of our place that a three inch paving was satisfactory. We have had such

pavement in use now for five years and it is saving us a whole lot of money. The maintenance of a gravel or cinderized yard is considerable, especially with trucks running across it, and we put in three inches of concrete which has stood up very nicely. It saves in the cost of piling. Instead of having driveways alone and instead of carrying block say, six feet, you can take your truck and bring your blocks up to the exact point where you want to pile it, and the man can take the block off the truck and pile it on to the regular pile. It will also in many cases, make a better pile, for it will often be difficult to pile block nine or ten high on cinders, gravel etc., if you want to separate them in piling. Under ordinary conditions one tier of blocks will support the next tier, but if you separate them it will be necessary to have a very even footing, and a paved yard would eliminate the trouble from block falling over.

It seems to me that consideration should be given to the fact that in using lift trucks wider curing rooms are necessary, especially in view of the fact that the pipes are on the inside. I notice it was twelve inches from the edge of the rack. A block may overhang about four inches and you only have left about eight inches. Four inches of that space may be used up with your piping and you have but four inches left for clearance. It is very difficult for the man operating the lift trucks to set the racks in such a way that he can have easy access. As far as piling block is concerned, you must take into consideration the difference between using block or tile for back up, and block or tile used for exteriors. A block piled horizontally will generally be scraped as the men place the block horizontally and as they are taking it from the pile, they naturally pull them. You may tell them a thousand times to lift them, but they won't do it, and as they pull them, little particles of sand will start scratches on the block.

Readers are referred to the JOURNAL *for October, 1931 (Vol. 28) for further discussion which may develop. Such discussion should reach the Secretary by Sept. 1, 1931.*

Discussion of Paper by C. A. Hughes and A. S. Levens:

"Strength and Shrinkage of Mortars Made with Blends of Portland Cement and Pozzuolanic Materials"*

BY LEWIS H. TUTHILL†

Several years association with the problems of mass concrete have strengthened the conclusion that plain portland cement concrete has serious deficiencies when used in this manner. More than two years ago this led to a beginning of studies of the effects of pozzuolanic co-mixtures with portland cements. About the same time contemporary work was started in three other field and industrial laboratories in California.

In many ways the paper was an excellent check on our work with Fresno pumicite, (mentioned as F in the paper under discussion) but the conclusions enumerated, although correct in the light of several independent series of similar tests, do not bring out the importance of the possibilities of the use of this and similar pozzuolanic material with portland cement—particularly in mass concrete. It is also felt that certain of the tests were over too short a period to demonstrate the ultimate action of a slow working material of this kind. This applies particularly to the strength tests, and to the shrinkage tests which were terminated just at the point where there was a decided indication that time and age materially reduced the tendency toward volume change in these concretes. In a concrete dam, for instance, it is not only what may happen in the concrete the first few months that is important, but also, its probable behavior through the first few hundred years.

*A. C. I. Journal, December 1930; *Proceedings*, Vol. 27. p. 317.

†Concrete Technologist, Los Angeles, Calif. (Exchequer, Melones, Pardee and Calaveras dams).

The use of the visual test tube method was an excellent independent check upon our method of proving the material under consideration to be a true pozzuolana. Our method was to make a water paste of two parts of pumicite to one part of hydrated lime and cast 2 x 4 in. cylinders. These specimens attained a strength of 400 lb. per sq. in. in a month while pastes of the individual ingredients mixed separately remained soft. Both of these methods and results satisfy the requirements of the accepted definition: "A substance is said to be pozzuolanic when, while not necessarily cementatious by itself, it possesses constituents which will combine with hydrated lime at ordinary temperatures in the presence of moisture to form stable insoluble compounds of cementatious value."

Compression tests of concrete made by the writer are submitted to show the effect at one year. The early lag and later catching up in strength is the same for the concretes as for the mortars discussed in the paper. Richer and drier concretes, and concretes of lower fineness modulus. show the same trend of strength increase but with an increasing period (from six months to two years) before the equivalent of the concrete in which no pumicite is substituted for cement is reached. This lag in strength is not a matter for concern where high early strength is no object as long as its ultimate attainment is assured—and it is assured, for pozzuolanic concretes show far more consistent and uniform time increase strength ratios than do the plain cement concretes. As long as the practical minimum strength necessary safely to sustain early loads is attained, the delay in reaching equivalent or usually superior ultimate strength is unimportant compared with the advantages of pozzuolanic concretes in reduction of heat liberated on setting, in fixing in an insoluble form the usually soluble lime compounds, and, particularly, in consequent durability and permanence of the structure.

Aside from establishing the fact that concretes, in which the pumicite is substituted for a portion of the cement, will attain the same or greater strength than the plain concretes with greater uniformity and without retrogression, it is submitted that in the above tests is an indication of the pozzuolanic char-

EFFECT ON COMPRESSIVE STRENGTH AT VARIOUS INTERVALS OF SUBSTITUTING FRESNO PUMICITE FOR CEMENT BY VOLUME

Per Cent Pumicite	Actual Cement bbl./c.y.	Actual Water-Cement R.*	Slump	Fineness Modulus	Strength 28 Days†	Strength 3 Mos.†	Strength 6 Mos.†
None	.94	1.09	6–8	6.57	1455	1600	1775
					1.00	1.10	1.22
10	.85	1.13	6–8	6.57	1302	1679	1867
					1.00	1.29	1.43
20	.76	1.16	6–8	6.57	1098	1469	1713
					1.00	1.34	1.56
30	.67	1.19	6–8	6.57	996	1477	1772
					1.00	1.48	1.78

*In addition to water here indicated, water was added for absorption of the aggregates and an amount equivalent to 60 per cent of the weight of the pumicite.

†Each strength value is the average of two 8 x 16 in. specimens, each from a different batch assembly. One specimen for each period was made from each batch. Aggregate 3 in. maximum.

NOTE: It was plainly noticeable, particularly in this wet consistency, that as the amount of pumicite substituted increased, the mixture became harsher as to workability. This is believed due to the lower absolute volume and mass in an equivalent volume compared with cement which reduces the lubrication. In order that workability be maintained, particularly where the remaining cement is less than 1 bbl. per cu. yd., substitution by weight is recommended.

acter: combination of lime and silica to form the strength giving (as well as insoluble) calcium silicates. For instance, in the first series the ratio of increase, 28 days to 6 months, for plain concrete is 1.22; for 30 per cent substituted pumicite it is 1.78—an increase of .56. Where does this extra margin of strength come from? Certainly not from the aggregate. The cement has gone its limit at 1.22. Free lime and soluble silica are present. Cement chemists generally agree that calcium silicates are the strength giving elements of cement. It would seem evident that some such combination of these two ingredients had been formed.

As a matter of fact all contemporary work on this subject has uniformly and consistently proven the characteristic pozzuolanic reaction with free lime of this pumicite and other available American materials. The existence of a percentage of free lime in all cements—varying in amount from brand to brand—and

EFFECT ON COMPRESSIVE STRENGTH AT VARIOUS INTERVALS OF SUBSTITUTING FRESNO PUMICITE FOR CEMENT BY WEIGHT

Test No.	Per Cent* Fresno Pumicite	Actual Cement bbl./c.y.	Maximum Size Aggregate	Slump	Fineness Modulus	Strengths Are Average of Two Tests			
						28 Days	3 Mos.	6 Mos.	1 Year
WP5	None	1.16	1½ in.	5	5.35	2082	2610	2888	2907
						1.00	1.253	1.387	1.396
WP4	14	1.00	1½ in.	5	5.35	1866	2438	2746	2978
						1.00	1.306	1.472	1.596
GT2	14	1.00	1½ in.	5	5.35	1970	2578	2870	2984
						1.00	1.308	1.456	1.514
AD2	None	1.111	1½ in.	6–7	5.61	2120	2548	2470	2442
						1.00	1.202	1.165	1.152
AD6	10	1.00	1½ in.	6	5.61	1906	2474	2579	2494
						1.00	1.297	1.35	1.307
AD4	10	1.00	1½ in.	6	5.61	2030	2434	2090	3146
						1.00	1.198	1.32	1.548
AD3	None	1.25	1½ in.	6	5.61	2998	3271	3477	3109
						1.00	1.09	1.16	1.036
AD5	20	1.00	1½ in.	6	5.61	2388	2735	2862	3242
						1.00	1.144	1.19	1.357
AD7	20	1.00	1½ in.	6	5.61	2048	2643	2955	3275
						1.00	1.289	1.44	1.598
AD1	None	1.00	1½ in.	6	5.61	2032	2348	2360	2323
						1.00	1.156	1.162	1.144
21	12.5	1.19	1½ in.	5–7	5.35	2537	3060	3230	3515
Job						1.00	1.206	1.263	1.385
Tests									

*The percentage of pumicite is the percentage of the cement plus pumicite.

NOTE: In all the series AD two year specimens were made. Tests will be made on these at the proper time in the fall of 1931.

the disastrous effect of its solubility in the dissolution and decay of hydraulic and sea water structures in apparently recognized in this country as evidenced by numerous articles and references on this phenomenon. But so far, indirect rather than fundamental measures have been generally taken to combat these results. We must confess that the Europeans are somewhat in the lead of us in the solution of this problem by the recognition of the effect of using pozzuolanic co-mixtures with their portland cements. Some quotations from European publications and statements in limited circulation are believed to be pertinent and instructive.

From Paper No. 693—"Scientific Researches on Pozzuolana Substances," by A. M. Manonilov, Director of the Mechanical Laboratory of the Moscow Institute of Transport Engineers:

The scope of the question may easily be gaged from the fact that 14 papers, bearing on the decay of portland cement in water, were delivered in English, Swedish, Danish, Dutch, Belgian, French, Spanish and Japanese experts during the last International Congress on Navigation held in London in 1923.

All these numerous scientific labors in investigating the decay of portland cement in water have definitely shown that the cause of this decay is not to be assigned to faulty work in building concrete structures; nor to faulty portland cement used in the cases in question; but is inherent to the very nature of portland cement, whose process of setting involves the formation of a quantity of hydrate of CaO (which is $Ca(OH)_2$ easily subject to solution in water and to gradual alkalization. These researches have conclusively shown that it is to this particular process of alkalization of the $Ca(OH)_2$ that the weakening of concrete and its subsequent decay is due. In the presence of sulphates, usually found in sea water, the process of decay of portland cement is considerably accelerated owing to the additional chemical reactions tending to form lime sulpho-aluminate: 3Ca) Al_2O3 3Ca SO_4 $3OH_2O$. This formation of lime sulpho-aluminate results in huge increase in volume which in turn is followed by the formation of numerous cracks increasing the permeability of concrete to water and contributing to a quicker alkalization of $Ca(OH)_2$. In the presence of magnesial salts in water soluble calcium salts are formed which can be easily washed away by water.

Thus, since the law of decay of portland cement in water was established, the question naturally arose of finding means to prevent this process of destruction.

* * *

After extensive scientific investigations had been started, all the countries concerned soon came to the conclusion that the best, the simplest and cheapest method of preventing the decay of portland cement in water was that of introducing pozzuolana aggregates into the concrete, the "active silica SiO_2

being the main component of the above aggregate. The prevention of decay of portland cement in this case consists of the active silica SiO_2 binding the hydrate of calcium oxide $Ca(OH)_2$ and thus creating the combination $CaO\ SiO_2\ 2\frac{1}{2}H_2O$ which is next to insoluble in water. Another favorable factor in that the possible formation of destructive lime sulpho-aluminate $3CaO\ Al_2O_3\ 3Ca\ SO_4\ 30H_2O$ is altogether eliminated provided only a sufficient quantity of active silica SiO_2 is available.

* * *

Port structures at Odessa, Yalta, Feodossia, Novorossijsk, Poti, Batum and Petrovsk were inspected, and so also were the dry docks in Sebastopol and Baku. The piers in these ports were built after the Marseilles type. Standard portland cement was made use of in all these structures, excepting only those of Odessa and Poti where Roman pozzuolana and Teil lime were employed along with portland cement. The results obtained from the inspection of concrete structures in South Russian ports of the Black and Caspian seas led to the same conclusions with regard to the decay of portland cement in sea water which at that time had already been arrived at abroad. The inspection showed that visible symptoms of decay could be already observed seven years after immersion; a considerable degree of decay was observable in the course of 13-14 years, and complete destruction took place in 25-30 years. (where only portland cement was used).

Two pertinent conclusions were:

(1) Extensive scientific analytical work was carried out in tracing the true cause of this decay and resulted in the same conclusions which were also arrived at by scientists of other countries. The research resulted in raising full scale the question of the tremendous value of pozzuolana substances.

(2) In connection with the scientific and industrial conclusions obtained as to the expediency of applying pozzuolana substances, the question has been given these last ten years such great attention in the USSR that pozzuolana substances are incorporated in the official Matrice Standards as a substantial item thereof.

[Mr. Tuthill also refers to "Building Research Bulletin No. 2—Pozzolanas" of the Department of Scientific and Industrial Research, England, and to discussion by Prof. Lingi Luiggi, (Italy) of a paper by J. B. Lippincott describing the successful use of pozzuolanic material ground with cement in construction of the Los Angeles aqueduct, *Transactions* of the *American Society of Civil Engineers*, 1913, Vol. LXXVI, pp. 567-9.—Editor]

So it would appear from international research, experience and opinion (including our own), which conforms so well from one source to another, that it is true that:

1. Portland cement concrete is improved by the inclusion of an intimately mixed pozzuolana by reason of its combination with otherwise free and soluble lime to form insoluble and enduring compounds.

2. From centuries of experience of the durability of lime-pozzuolana compound mortars and concretes, it may be taken for certain today that there will be certainly no decrease, and most likely an increase in the durability and permanence of concretes in which some pozzuolana of proven reaction with lime is used as a co-mixture with portland cement.

3. Available American materials are equal or superior to similar materials used so widely abroad with profit and success, and otherwise unusually permanent results.

All that has been accomplished to date in volume change studies is a classification of causes and effects, and a recognition of the factors increasing and those decreasing this unpleasant phenomenon in concrete—particularly in massive work.

It is evident that with present day materials and the best of practice, volume change cannot be eliminated. Fortunately the best practice to other ends results in minimum volume change (avoidance of excess water and fines, and thorough curing). It should be admitted that volume change is a property of concrete which must be recognized and provided for in design the same as its strength or its weight.

In this light, any slight variation more or less in volume changes caused by the use of any particular ingredient is not important. It is a property that should be otherwise recognized and properly taken care of in design, and if this is properly done, variations of a few per cent would be of no actual importance—especially when attended by such important improvements in the other characteristics of the concrete as described above. Although Fresno pumicite (like any other extremely fine ingredient) slightly increases shrinkage on drying, structures in which this pozzuolana was used show less cracking than other structures in similar circumstances but made with plain concrete. This may be because pozzuolanic concrete is enough more elastic to offset any increment of increased shrinkage factor. Experiments have shown a ten per cent reduction of modulus of elasticity for such concretes.

BY F. M. LEA*

Messrs. Hughes and Levens refer to the method of the Building Research Board for estimation of the activity of pozzuolanas.

*In charge of research on pozzuolanic materials, Building Research Station, Garston, Watford, England.

This method has now been replaced by a more accurate quantitative method.[1] The pozzuolana is ground to pass a 180 mesh to the inch sieve and its rate of reaction at 25 deg. C. with a N/30 $Ca(OH)_2$ solution, when mixed in the proportion of 0.5 gm. solid to 125 cc. solution, measured by an electrical conductivity method. Initially an adsorption of $Ca(OH)_2$ takes place, but this adsorption bears no relation to the pozzuolanic activity of the material. It is followed by a steady combination reaction between lime and pozzuolana and the mean rate of this action between the twentieth and forty-fifth hours after mixing is defined as the activity of the material. The activity figure so obtained is a good index of the pozzuolanic properties of the material at early ages up to about 28 days, but it does not afford any measure of, for instance, the strength which will be developed at longer ages.

Some typical activity figures are shown in the following table.

RELATIVE ACTIVITIES OF POZZUOLANAS AT 25 DEG. C.

Pozzuolana	*Activity.* (mgm. $Ca(OH)_2$ removed per 1000 mins. by 0.5 gm. pozzuolana from 125 cc. $Ca(OH)_2$ solution).
Burnt clay A	7.2
B	10.5
C	6.0
D	3.3
Scottish spent oil shale A	7.5
B	6.0
C	5.0
Trass A	2.9
B	1.2
C	4.7
Santorin earth A	2.9
B	1.1
Italian pozzuolana	2.4
Granulated blast furnace slags	0–3

The two naturally occurring volcanic rocks F and P studied by Hughes and Levens appear from their results not to differ widely from the European naturally occurring pozzuolanas such as trass and Santorin earth. Extensive studies on the production and properties of pozzuolanas which have been in progress for some years at this Station have shown that artificial pozzuolanas

[1] c. f. Annual Reports of the Building Research Board, 1926-1929.

can be produced which are markedly superior to the naturally occurring materials. Such materials are selected clays burnt at predetermined and controlled temperatures, and the spent oil shale of the Scottish shale oil industry. These materials are ground to a residue of a few per cent on a 180 mesh to the inch sieve for use as pozzuolanas. It is doubtful if granulated blast furnace slag is to be regarded as a pozzuolana in the strict sense of the term since this material does not combine very appreciably with free lime in set mortars or concretes.

The properties of a pozzuolana may be determined and compared in a number of ways, but the most useful are initially an activity test by the conductivity method mentioned above followed by tensile strength tests on lime-pozzuolana-sand briquettes stored under carbon dioxide-free conditions. These tests can then be followed, if results warrant it, by tensile strength tests on cement-pozzuolana-sand mortars and compressive strength and other tests on concretes. Measurement of the free lime present in set cement-pozzuolana mortars and concretes is another important and valuable method for assessing the value of pozzuolanas. Suitable methods for these determinations have been developed.[2] The substitution of 40 per cent cement by an active pozzuolana of the spent oil shale or burnt clay type reduces the free lime content of a water stored 1:3 cement-sand mortar from about 2.0 per cent to 0.8 per cent at 7 days, from 2.3 per cent to 1.0 per cent at 28 days and to about 0.7 per cent at 6 months.

The suggestion made by Hughes and Levens that prolonged moist air or water curing is necessary for the satisfactory utilization of pozzuolanas seems to apply more to the naturally occurring materials than to the artificial products. This is well illustrated by some data on the tensile strength of 1:1:6 pozzuolana-hydrated lime-standard sand mortars. The briquettes were similar to those specified in the British standard specification for portland cement except that mechanical methods of mixing and ramming were employed. This substitution of mechanical for hand methods has no very marked effect on strength. Results are the mean of six briquettes tested in the same conditions as stored.

[2]A general account of these methods will appear in Building Research Special Report No. 17 to be published shortly.

TENSILE STRENGTH 1:1:6 POZZUOLANA : HYDRATED LIME : STANDARD SAND MORTARS STORED AT 12-13 DEG. C.

Pozzuolana	Tensile Strength lb. per sq. inch									
	Dry stored					Water stored				
	7 da.	28 da.	3 mo.	6 mo.	1 yr.	7 da.	28 da.	3 mo.	6 mo.	1 yr.
Scottish spent oil shale	169	280	344	324	400	107	207	341	466	521
Burnt clay	192	296	373	391	393	155	263	337	387	400
Santorin earth	41	110	143	201	...	8	62	306	446	...

Considerably higher strengths are obtainable in lime-pozzuolana mortars in which the ratio of lime to pozzuolana is decreased while keeping constant the ratio of pozzuolana plus lime to sand. The effect of temperature on pozzuolanic activity is very large and in tests on lime-pozzuolana mortars at least careful control of storage temperatures is essential. This is particularly noticeable with the naturally occurring pozzuolana Santorin earth which gives such low strengths over short periods at 12-13 deg. C. The tensile strengths at 7 and 28 days of water stored 1:1:6 Santorin earth-hydrated lime-standard sand mortars stored at 25 deg. C. were 45 and 250 lb. per sq. inch, or some four to five times the strengths developed at 12-13 deg. C.

Hughes and Levens find large reductions in the compressive strength of 1:3 cement-sand mortars at early ages when the volcanic earths are substituted for cement. This is similar to the results found with trass. The substitution of 40 per cent cement by trass results in about 50 per cent reduction in strength at 7 days and about 40 per cent at 28 days in 1:2.6 concrete mixes at a constant slump of either ½ inch or 2 inches. In 1:5 mixes the corresponding reductions in strength are about 65 per cent at 7 days, 55 per cent at 28 days and 45 per cent at longer periods. The water:cement × pozzuolana ratio required for a given slump is increased by the substitution of trass for cement. Relatively few data are as yet available on the compressive strengths of concretes with shale and burnt clay pozzuolanas, but from preliminary results it appears that the strengths obtained are much higher than when trass is used. The tensile strength of 1:3 cement:sand mortars is slightly increased at 7 days by the substitution of 20 per cent of the cement by a spent shale or

burnt clay pozzuolana and decreased 5-15 per cent by the substitution of 40 per cent, but at 28 days the unsubstituted cement mortar strength is exceeded by 10-20 per cent in the first case and by 0-15 per cent in the second. For all amounts of substitution down to a 40 per cent cement 60 per cent pozzuolana mix the ultimate (1 year) tensile strengths of the pozzuolana-cement mortars equal or exceed those of the mortar made from unsubstituted cement.

A short account of some of the main lines of investigation on pozzuolanas that have been carried out will appear in the Annual Report of the Building Research Board for 1930.

Readers are referred to the JOURNAL *for October, 1931 (Vol. 28) for further discussion which may develop and for the authors' closure. Such discussion should reach the Secretary by Sept. 1, 1931.*

Discussion of a paper by U. T. Berg:

"Continuous Beams and Frames in Building Construction"*

AUTHOR'S CORRECTION

On page 363—Table 3

For $\frac{I_h \cdot L}{H' \cdot I} = 0$, the bracket for K_s should include P and N values, and K_d should apply to the D values only.

On page 371

$H' = H$ is incorrect for condition of loading as shown, Fig. 9B. As column moments are of constant value throughout $\phi_2 = \frac{H}{2\,E\,I}$ and consequently $H' = \frac{3}{2}\,H$.

*A. C. I. Journal, December 1930; *Proceedings* Vol. 27, p. 359.

Discussion of a paper by F. E. Richart and V. P. Jensen:

"Tests of Bonding Floor Finish to Slabs of Haydite and Gravel Concrete"*

DISCUSSION

BY JOHN G. AHLERS†

The data presented in this paper confirm experience gathered from practice in the field; that it is possible to apply cement finish to structural slabs within 24-hours and have them act as an integral part of the structure.

This paper should bring to engineers and architects the conclusion that specifications should be written so as to allow contractors to place floor finish within 24-hours of the pouring of the slab and have these considered as monolithic and part of the structural slab.

Experience in the past has shown that where careful construction methods are followed one inch finish, placed afterwards, can be made to bond thoroughly with the structural members and the data presented confirms what has been observed in practice.

As might be expected, this paper shows that there is equally good bonding between structural slabs of haydite and structural slabs of gravel-concrete.

BY M. A. TIMLIN

Messrs Richart and Jensen show definitely that there is no inherent defect in the bond of a rich floor finish to a base of Haydite concrete. It would seem at first that the bond of the Haydite concrete was better than with the gravel concrete since failure occurred in the concrete itself immediately below the bonding plane in the former and entirely in the bond in the latter. A definite conclusion to this effect can not, however, be drawn from the data available.

*A. C. I. Journal, December 1930; *Proceedings* Vol. 27, p. 339.
†Barney-Ahlers Construction Corp., N. Y. C.

It would be difficult if not impossible to evaluate the strength of the bond from these tests. In the gravel concrete and the floor finish the moduli of elasticity were nearly enough the same that the slabs would act practically as simple beams with relatively low shear stress between the finish and base course.

On the other hand, with a finish having a modulus of elasticity of 4,030,000 lbs. per sq. in. superimposed on a Haydite base course with a modulus of elasticity ranging from 920,000 to 1,860,000 lbs. per sq. in., depending on the proportions used, when the load is applied to the slab the Haydite concrete tends to compress throwing greater load into the finish course. When this occurs, for each unit of load applied, greater stress exists in the finish course and less stress in the base course than when gravel concrete was used and the moduli of elasticity were more nearly equal. This of course causes greater shear stress.

If failure of the bond had taken place before failure of the reinforcement it might be possible to compute what shear stress had existed at the time of failure. Since initial failure of the reinforcement occurred first this can not be done. As soon as such failure took place the concrete in the base course was immediately placed in tension while the finish was still in compression. Just what these two stresses were can not be determined and consequently the shear stress is an unknown quantity, but would undoubtedly be greater in the case of Haydite concrete and greater in the lean than in the richer mixes.

Since the finish on the Haydite slabs had pieces of the base course adhering to them, indicating failure in the Haydite concrete immediately below the bonding plane rather than in the bond itself, it would appear that the shear strength of the bond were greater than the shear strength of the concrete.

With the gravel concrete base, the shear strength of the concrete exceeded that of the bond.

Therefore if the shear strength of the concrete is a function of the compressive strength only, the bond to the Haydite concrete was better than to the gravel concrete since the richer Haydite mixture had higher compressive strength than the leaner gravel mixture. If however, the shear strength depends also on the

modulus of elasticity and other factors, as it probably does, this line of reasoning will not apply.

A point of particular interest brought out by Messrs. Richart and Jensen is that the finish course took a large part of the load, particularly in the slabs with lean base courses and should be figured as part of the slab thickness.

There are a number of questions which arise as to actual behavior in a floor which are not covered by these tests, but which should be given serious consideration. Probably the most important of these is the differential expansion and contraction due to differences in moisture and temperature conditions. This has long been recognized as an important factor where a rich finish is used on a lean base course of gravel concrete. Since this is so where the differences in the coefficients of expansion are low, it would be of far more importance between gravel topping and Haydite base where the differences in the coefficients of expansion are probably of greater magnitude. The importance of this point could be determined only by laboratory tests showing the differences in expansion of two types of concrete under varying conditions of moisture and temperature.

While we have no data bearing on the resistance to impact of a floor consisting of base course of Haydite and a rich gravel concrete finish, it is logical to assume that such resistance would be at least equal to that of a gravel concrete base. Concrete made with an aggregate having the characteristics of Haydite would serve as a cushion and be able to absorb impact transmitted to it through the finish course better than a more rigid material. There should, therefore, be less tendency to crack or to split off from the finish course.

The report under discussion is based on tests made to show the behavior of a slab having the rich finish course in compression as in the case of a slab between supports. It would be interesting to know what the action would be when the compression is taken entirely by the lean base course and the finish course is in tension, and the slab of course properly reinforced, as in the case of a slab passing over a beam or attached to a wall.

ABSTRACTS

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of the current literature of cement and concrete

PREPARED UNDER THE DIRECTION OF THE
AMERICAN CONCRETE INSTITUTE
COMMITTEE ON ABSTRACTS

J. C. WITT, Chairman, (*Materials*)
H. F. GONNERMAN (*Properties of Concrete*)
F. E. RICHART (*Engineering Design*)
REXFORD NEWCOMB (*Architectural Design*)
THEODORE CRANE (*Field Construction*)
W. D. M. ALLAN (*Shop Manufacture*)

EDITED BY DWIGHT F. JENNINGS

ABSTRACTORS

JOHN E. ADAMS
F. O. ANDEREGG
ROBERT W. ABBETT
ODD ALBERT
A. G. ALEXANDER
S. O. ASPLUND
C. BACHMANN
P. H. BATES
A. A. BRIELMAIER
A. E. BEITLICH
MILES N. CLAIR
C. G. CLAIR
IRA L. COLLIER
M. A. CORBIN
R. J. DIETRICH
E. L. ERIKSEN
H. FRAUENFELDER
W. I. FREEL
P. J. FREEMAN
H. J. GILKEY
A. T. GOLDBECK
J. E. GRAY
E. S. HANSON
S. C. HOLLISTER
A. J. HOSKIN
F. H. JACKSON
V. P. JENSEN
D. E. LARSON
H. WALTER LEAVITT
L. G. LENHARDT
A. E. LINDAU
ARTHUR R. LORD
H. J. LOVE
P. MCKIM
JOSEPH MARIN
N. D. MITCHELL
R. B. B. MOORMAN
GLEN MURPHY
REXFORD NEWCOMB
J. C. PEARSON
C. E. PROUDLEY
F. E. RICHART
N. H. ROY
J. H. SHANK
EDMUND SHAW
A. SIZE
T. U. TAYLOR
T. THORVALDSON
G. E. TROXELL
H. S. VAN SCOYOC
STANTON WALKER
G. M. WILLIAMS
C. R. YOUNG
ROY N. YOUNG

MATERIALS

ADMIXTURES

The chemistry of Rhenish trass. HEINRICH HART. *Tonind. Ztg.* (Germany). Jan. 15, 19, 1931, V. 55, No. 5, 6, pp. 65-6, 84-6. By means of solutions of benzene in bromoform, trass from different places along the Rhine was separated into several fractions. Trass is of variable mineralogical composition and seems to be an alkali aluminosilicate in varying stages of hydrolysis. —F. O. ANDEREGG

Cement admixtures, their action and absorbing power. P. MECKE. *Tonind. Ztg.* (Germany). Jan. 8, 1931, V. 55, No. 3, p. 33-6.—A few tests, made with rather large amounts of water glass, oleic acid or other water repellent substances, did not yield very encouraging results.—F. O. ANDEREGG

AGGREGATES

Specifications for sand, gravel and crushed stone. *Tonind. Ztg.* (Germany), Jan. 5, 1931, V. 55, No. 2, p. 21-2.—Using woven wire sieves up to 1 mm. and round openings for separating larger sizes, separations of aggregates are made at openings: .0024, .0035, .0079, .0236, .0394, .118, .276, 3/8, 5/8, 3/4, 1 1/4, 2, 2 3/8 and 2 3/4 in. For railroad ballast separation is made at 3/8, 3/4, 1 1/4 and 2 3/8 in.—F. O. ANDEREGG

Tentative standard specifications for gradation of sand, gravel and broken stones. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 37-8.—Report is given of third meeting of committee for standardization of aggregate grain sizes, held on Oct. 31, 1930 in Berlin (Germany). Specifications cover natural sands and gravels, broken rocks, concrete aggregates and materials for railway roadbed construction work. New fixed definitions for certain grain sizes are proposed.—A. E. BEITLICH

Thermosit compared with natural pumice. HEINRICH HART. *Betonwerk* (Germany), Aug. 3, 1930, V. 18, No. 31, p. 432.—Chemical analysis, comparative porosity, weight, capillarity and strength of both natural pumice and artificial pumice, "Thermosit" are discussed, and the use of these materials as a light weight aggregate in actual work described. The article is fully illustrated with reproductions of photographs and tables of tests.—HERMAN FRAUENFELDER

The application of protective mortar coatings containing metal aggregates. GEORGES DUPONT. *Ciment* (France), Dec., 1930, V. 35, No. 12, p. 462-74.—Concrete exposed to sea water and other conditions where it is subjected to chemical or frost attack or to erosion by flowing water should receive an impermeable and durable protective coating. Metallic aggregates are often suitable for making mortars with cement for this purpose.—F. O. ANDEREGG

Inert aggregates and the mechanical properties of concrete. R. DUTRON. *Rev. des materiaux construction trav. publics*, July to December, 1930, No. 250 to 255.—Article in six instalments emphasizes importance of nature, shape and grading of inert aggregates. Highest compressive strengths are obtained with concretes using river sand and gravel, rounded in shape and well graded. The elastic coefficient being a direct function of compression strength, the same applies in this connection. The reverse order prevails, when results of tensile and flexural strength are considered. The rounded aggregates of river origin yield lowest tensile strengths. Ratio of tensile to compressive strength of concrete varies with age of concrete and with aggre-

gate used. It is highest for crushed aggregate and lowest for river sand and gravel. This ratio varies from 1/10 to 1/20, when compressive strength is tested on 7.9 in. cubes. Shear is a linear function of compressive strength. Its ratio to the latter varies from 2/10 to 3.5/10, when tested on cubes with cross section of 62.0 sq. in. Impact strength is greatly affected by the nature of inert aggregates, the rounded river sand and gravel being most brittle.—M. A. CORBIN

Laboratory studies in the prevention of segregation. A. T. GOLDBECK. *Crushed Stone J.*, Nov., 1930, V. 6, No. 11, p. 3-7.—The theory of segregation is stated as follows: When aggregate, falling in a single stream, piles up in the form of a cone, surface voids entrap pieces of smaller diameter, therefore causing pieces of larger diameter to roll to the outside. Studies were made to develop a method to prevent piling up of material in the form of a cone. A model bin and railroad car were constructed to scale of one inch to the foot and stone screenings approximately the same scale were used for aggregate. Ten possible methods of preventing segregation were investigated. Of these, two gave promise; the single balanced gate and the double balanced gate. The single balanced gate is recommended because of its simplicity. It is a hand operated swinging plate pivoted under the center of the stream at a point one-third of the way down from the top. This distributes the aggregate in a horizontal layer laterally across the car, thus preventing segregation.—J. E. GRAY

High quality aggregates and value of concrete. PAUL HERTEL. *Zement* (Germany), Nov. 13, 20, 27, Dec. 4, 1930, V. 19, No. 46, 47, 48, 49, p. 1087-90, 1117-21, 1141-4, 1167-9.—Investigations were made as to how quality and costs of concrete can be improved by changing gradation of aggregates according to sieve curves now in practice. Following methods are discussed: (1) Fuller curve takes aggregates and cement into consideration, (2) curve by Herrmann is similar to Fuller curve but gives a greater number of sizes between 0.12 and 0.47 in. and does not consider cement content, (3) Graf emphasizes importance of fine aggregates and gives a favorable mortar curve, (4) Gruen established a void-volume curve. He determines volume of voids of aggregates by filling a cylinder with coarse particles and water and then replacing water by fine aggregate. (5) Otzen derived an ideal curve, similar to Fuller curve which shows directly grain composition of aggregates for certain mixtures, or cement contents per cu. ft. Great number of experiments were made to study effect of improving aggregates by means of above described curves on yield, consistency, weight per cu. ft., compressive strength, flexural strength and water permeability. One blast furnace slag cement and one high alumina cement were used for these tests. In all cases 18.7 lbs. cement were used for 1 cu. ft. of concrete and consistency of all mixtures was plastic. Results show clearly that properties of concrete are greatly improved by such methods, especially water impermeability. Costs of concrete are in general about 20 per cent higher when aggregates are treated in such manners.—A. E. BEITLICH

Control and improvement of the granular composition of sand, pit gravel, and fluvial deposits used in the manufacture of concrete. A. JANOUSEK. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—River deposits excavated for use in concrete have only exceptionally the composition required. To control this composition, it is essential to carry out a grading analysis, which should be executed with all possible care. Attention should be paid to following points: (1) Diameter and geometric shape of grains, in relation to strength. (2) Surface area of single grains, and of total of grains collectively, in relation to strength. (3) Proportion of grains of any one diameter, and relation between various diameters. (4) Means of employing these results for improving granular composition of material. A common in-

direct procedure consists of sieving mixture in a series of sieves, thus measuring the granular composition of a given quantity of material. The surface area of the grains can be determined, although only approximately, by either an experimental or a mathematical method, both of which are based on results of sieve analysis. To use the results of these investigations rationally and economically, it is necessary to organize continuous control on the building site. In addition it is desirable to control mixing of concrete, and to mechanize operations as much as possible with object of eliminating personal influence of incompetent workers. There is at present no sufficiently accurate experimental method for determination of surface area of gravel, but directions are given for calculation of this quantity, a knowledge of which is most important, particularly in connection with tensile strength. In addition the question of international unification of methods of control has been studied, and various propositions elaborated. The essential requirement is a series of sieves having circular holes, .039, .118, .275, .590 and 1.180 in. or .039, .078, .197, .394 and .787 in. in diameter. The natural limits of application of the grading modulus are dealt with, and finally a simple method of comparison of grading analysis curves is suggested for application in the correction of natural grading.

CEMENT

Tube mill grinding. BELLWINCKEL. *Zement* (Germany), Dec. 4, 1930, V. 19, No. 49, p. 1161-3.—Author attacks statements made by A. B. Helbig in previous article (*Zement* (Germany), Sept. 9, 1930, V. 19, No. 37, p. 870-3; JOURNAL A. C. I., Dec. 1930, V. 2, No. 4, *Abstracts*, p. 97), on superiority of tube mills with air separators over ordinary tube mill type. For an economic performance of a tube mill without air separator, the following points must be taken into consideration: (1) Entire length of mill must be divided into 3 or 4 sections, (2) form and weight of steel balls must correspond with increasing fineness of material, (3) separation of coarsest particles by screens and (4) sufficient aeration and cooling of entire mill. These points are discussed for raw mix, coal and cement.—A. E. BEITLICH

Tube mill grinding. A. B. HELBIG. *Zement* (Germany), Dec. 25, 1930, V. 19, No. 52, p. 1234-5.—In reply to article by Bellwinckel (*Zement* (Germany) Dec. 4, 1930, V. 19, No. 49, p. 1161-3), author again emphasizes advantages of air separator installations in tube mills and cites a number of American experiences.—A. E. BEITLICH

Tricalciumsilicate. ENRST JAENECKE. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 26.—After studying paper by L. T. Brownmiller and R. H. Bogue on "The X-ray method applied to a study of the constitution of portland cements," author admits existence of tricalciumsilicate, contrary to his former opinion. Furthermore he points out, that his compound jaeneckeit: $8CaO.Al_2O_3.2SiO_2$ can exist as found by X-ray measurements. He explains necessity of work with petrographic microscope and X-ray in portland cement clinker constitution problem.—A. E. BEITLICH

Cement and concrete in the graphic four-component parallelogram. M. SPINDEL. *Zement* (Germany), Dec. 18, 1930, V. 19, No. 51, p. 1200-5—A four-component diagram in form of a parallelogram is explained and its application advised for proportioning of cement mixtures, especially for high early strength cement. Allowable limit for lime content for manufacture of best cement, as calculated by Kuhl, Jaenecke, Guttmann and Gille are plotted in diagram and compared.—A. E. BEITLICH

Acceptance and control tests for cements. QUIRINO SESTINI. *Ostr. Bauzeitung* (Austria), Dec. 13, 1930, V. 6, No. 50, p. 810-1.—Author claims that ordinary tests do not give a true picture of all properties of cement. Behavior with different aggregates and retarding or preserving agents are not

considered. Opinions of A. J. Poole and C. R. Platzmann on subject of cement testing are discussed. An empirical formula for valuation of cement is derived which gives a relation between compressive strength C and tensile strength T. $R = \frac{T \times 10 + C}{2}$ R is quality factor. (*cf. L'Industria Italiana del Cemento* (Italy), July, 1930.)—A. E. BEITLICH

Determination of soluble silica in puzzolan cements. G. BAIRE. *Chimie et Industrie* (France), March, 1930, V. 24, special number, p. 298-300.—A method is given for determination of soluble silica in puzzolan and mixtures of portland cement and puzzolan or trass. Sample of 1.0 gram is treated with 100 cc. cold water and 25 cc. hydrochloric acid (1.1 per cent). Residue is filtered after gentle heating, washed with hot water and dried. Then it is treated for 20 hr. in the cold and 4 hr. at 122 to 150° F. with 100 cc. of a solution of potassium hydroxide (20 per cent). Precipitate is washed and ignited, treated with sodium carbonate and analysis is then continued as usual.—A. E. BEITLICH

Protective coatings for cement and concrete. *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Nov. 21, 1930, V. 82, No. 47-48, p. 408-9.—Principle of most protective materials is formation of an inorganic coating which is more weather resistant and under certain conditions even harder than concrete surface. Fluorides, especially magnesium and zinc fluorides, are most important and effective when an excess of lime is present in cement. Of similar effect are silicate coatings on which a second protective coating is advisable. Silicate esters are used for same purpose lately. Coatings may be white or colored with inorganic pigments. Hardening process of these materials is in general very slowly. Coatings can be made which resist temperatures up to 1100° F. Coatings do not destroy natural porosity of concrete surface.—A. E. BEITLICH

A new method for the determination of consistency of cement mixtures. KARL E. DORSCH. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 26-8.—Inaccuracy of Vicat method for determination of normal consistency of cement-water mixtures led author to design new apparatus which gives more accurate results without use or waste of much cement. Procedure is as follows: 100 g. cement is mixed for 3 minutes with 28 per cent water and then filled into small conical steel cylinder open at top and bottom. (Lower opening is smaller than top opening.) Cylinder with cement is then dropped between two vertical steel rods of special support which has a stop near bottom. When cylinder hits stop a small amount of cement will emerge from bottom opening. Cement which leaves cylinder after 3 runs is collected and weighed in small porcelain crucible. Table shows normal consistency calculated from weights of cement. Method was found to be highly accurate for various cements. Dimensions and drawings of apparatus are given.—A. E. BEITLICH

Temperature and humidity control in cement testing. H. S. MATTIMORE. *Eng. News Record.* Jan. 1, 1931, V. 106, No. 1, p. 36.—Product termed "high-early-strength cement," is more sensitive to temperature and humidity conditions during testing than cement produced several years ago. Specifications allow a tolerance of plus or minus 5 per cent. In some cases this is too broad, as conditions have been experienced in testing high-early-strength cement where a maintained temperature of 65° F. resulted in rejection on strength requirements, whereas these requirements were met when a temperature of 70° or over was maintained. Standard specifications require that relative humidity shall not be less than 90 per cent in moist closet during storage of strength specimens. In Pennsylvania department of highways testing laboratory the special moist air cabinet is constructed with slate interior, 1 in. of cork insulation and steel exterior. Humidity is maintained from 95 to 98 per cent by running water flowing from perforated pipes in each

section down the sides of brass mesh screen mounted ⅜ in. from the side walls. Temperature of water is regulated in temperature control valves prior to entering the cabinet. Temperature records over many weeks indicate a maximum variation of 2°.—D. E. LARSON

Comparative investigation of effect of chlorides of calcium, barium and beryllium on setting process and strength of normal portland cement and portland cement without gypsum. K. FILL. *Zement* (Germany), Dec. 11, 18, 1930, V. 19, No. 50-51, p. 1178-84, 1206-9.—One portland cement clinker and one portland cement were mixed with aqueous solutions of calcium chloride, barium chloride and beryllium chloride and changes in setting time, compressive and tensile strength under different storage conditions were studied. Concentrations of solutions were 3, 2, 1, ½, 1/5 and 1/10 molar. Heat tones of reactions of cement and clinker with above solutions were measured and recorded in special insulated apparatus. Effect of these electrolytes on cement and clinker were considerably different, especially in case of $BeCl_2$ solutions. Strength of clinker is only slightly affected, while strength of cement is greatly reduced by $BeCl_2$. Calcium and barium chlorides improve in general strength of clinker and have similar effect as gypsum on setting time. Effect of these salts on heat tones is illustrated in several curves. Work was carried out in the Institute for Mineralogy of University of Frankfurt a. M. (Germany).—A. E. BEITLICH

Impermeability and permanence of cements. EDMOND MARCOTTE. *Ciment* (France), Dec., 1930, Jan., 1931, V. 35, No. 12, p. 476-82; V. 36, No. 1, p. 6-12.—The leaking of masonry walls is a subject of much concern and the attack of aggressive waters on concrete is to be connected with penetration of moisture into the concrete body. A complete investigation of the problem would require a very large number of experiments. After discussing briefly the properties of the several French cements the classic work of Michaelis on admixtures is reviewed in detail. The superior results obtained with European pozzolanic materials, especially in increasing resistance to sea water, is emphasized. A cement is now available made by grinding portland cement clinker with *gaize*, a pozzolan found near Paris and containing about 33 per cent alkali soluble silica.—F. O. ANDEREGG

Reconstruction of cement plant in Rodaun (Austria) *Ostr. Bauzeitung* (Austria), Dec. 20, 1930, V. 6, No. 51, p. 828-30.—New Quarry for raw materials was added to plant. Aerial ropeway delivers material to crushers. After passing dryers raw material enters 2 modern three-compartment mills directly driven by high speed motors and provided with table feeders. Material of any desired fineness can be obtained. Raw mix bins have capacity of 2640 tons. One rotary kiln, designed by Fellner and Ziegler, Frankfurt, is 164 ft. long and 9.8 ft. in diameter; it has an enlarged calcination zone. Kiln is provided with clinker cooler. Waste heat boiler system furnishes necessary electric energy. Gases from kiln and dryers are purified by electric dust precipitator. Entire coal mill was rebuilt and new tube mills installed. Plant manufacturers portland cement, high early strength cement and iron portland cement.—A. E. BEITLICH

Special carfloat used to distribute bulk cement. MORRIS KIND. *Eng. News Record*, Jan. 15, 1931, V. 105, No. 3, p. 111-112.—Bulk-cement delivery in New York City is complicated by fact that while most of cement is shipped from mills by railway, ultimate delivery with but a few exceptions must be by water. To secure quick, safe, economical delivery, bulk-cement cars and float have been constructed and used successfully. Cement is discharged from cars by gravity to a conveyor on the boat and then pumped to shore. There is no loss of cement and no dust. The float is equipped with a Diesel engine, generator, and compressor, and can handle 225 bbl. per hr. with total capacity of 3,500 bbl.—GLENN MURPHY

Special and fused cements—two Swedish products. VICTOR BAHRNER. *Teknisk Tidskrift* (Sweden), Jan. 3, 1931, p. 9-11.—These two types of cement that have been used in Sweden for several years, are made of almost same parts. Fused cement is produced as a melting substance. Compressive strength is very high, shown by following table summarized from several charts and diagrams:

	Compressive Strength in Lb. Per Sq. In. After				
	1 day	2 days	7 days	4 weeks	9 weeks
Melt cement	4260	5350	6130	6760	7460
Special cement	1570	2350	3560	4840	5270

The mix was 1:2:4 and the water coefficient 0.6. The time of setting is found to be very short, so the forms can be taken down and reused frequently. The fused cement heats up after pouring. Therefore concrete buildings can be built in freezing weather without being inclosed and heated. Several concrete houses have been constructed during the winters in Stockholm with excellent result. Table gives proportion of fused cement for different temperatures and thicknesses of concrete. It is necessary to keep the concrete from freezing 24 hours. Fused cement can not be mixed with portland cement or lime which will cause immediate set with low strength. The special cement can be mixed in same proportions as portland cement and fused cement concrete can not be made richer than 680 lb. per cu. yd. concrete. It should not be used if the temperature is more than 90° F. As a conclusion it may be said that special and particularly fused cement is suitable for all kinds of concrete construction where high compressive stresses and short construction time are required in freezing weather.—ODD ALBERT

Pre-determination of the composition of the concrete necessary to attain a given compressive strength. R. B. YOUNG. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—Method described has been widely used in the United States and Canada. It is based on Abram's water-cement-ratio-strength relationship and the soundness of this law for practical work is indicated. Details of method are outlined and typical data presented. Extensive references to original sources of information are included.—EDITORS N. I. A. T. M.

The degree of lime saturation. HESS. *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 28-32.—Degree of lime saturation (S) is described as relation between actual lime content and theoretically possible amount of lime in a clinker: $S = \frac{CaO}{2.8\,SiO_2 + 1.65\,Al_2O_3\,0.7 + Fe_2O_3}$. Replacement of hydraulic modulus in German Standard Specifications for Portland Cement by degree of lime saturation is proposed. Advantages of this new index are characterized and its application for valuation of clinker is clearly illustrated. Index can be easily demonstrated in graphs. Kuhl's method for use of this index is criticised and several improvements are suggested.—A. E. BEITLICH

Effect of storage conditions on the properties of cement. D. A. G. REID. *Concrete Constr. Eng.* (England), Feb., 1931, V. 26, No. 2, p. 155-159.—Investigation deals with effect of storage conditions on the rate of hardening of cements, particularly rapid-hardening cements. Factors investigated are: type of cement (normal portland, rapid-hardening portland, and aluminous); type of container (jute sack, four-ply paper sack, wooden keg, and metal drum); condition of storage (closed shed at normal temperature, cold storage, and oven storage) and period of storage (from 3 mo. to 2 yr). Conditions selected to represent what might actually occur in practice. General conclusions: (1) Loss on ignition increased with storage for all types of cement tested and all containers except the metal drum. (2) Appearance—after severe types of storage (jute and paper sacks and storage in shed) cement appeared coarser to the touch and in some cases air-set lumps were formed. (3) Water requirements for standard consistence rose steadily with increasing

loss by ignition. (4) Fineness—no change except due to air-set lumps. (5) Setting time—not always affected in the same manner or to the same extent. (6) Specific gravity decreased as loss by ignition increased. (7) Decrease in rate of attaining strength.—JOSEPH MARIN

PROPERTIES OF CONCRETE

Influence of proportioning of mix and water addition on mortar compressive strength of three cements of different values. ERICH SCHMIDT. *Zement* (Germany), Dec. 18 and 25, 1930, V. 19, No. 51-52, p. 1213-6, 1235-8.—In two extensive series of tests were studied influence of mix (proportions from 1:3 to 1:24) and influence of mixing water (from 4½ to 12 per cent) on mortar strength of one normal portland cement, one high early strength cement and one very high early strength cement (Zenith cement) with river sand. Curves for mortar strength development were in relatively close agreement with those from normal standard tests. Addition of water shows different effect according to age of specimen or kind of cement.—A. E. BEITLICH

Watertight brick masonry. F. O. ANDEREGG. *Contract Record Eng. Rev.*, Nov. 26, 1930, V. 44, No. 48, p. 1476.—In connection with study of watertightness of brick masonry which included tests of cement mortars it was found that ideal grading of sand for mortar is one of uniform increase in amount with size of sieve opening using a standard series of sieves whose mesh sizes differ by a constant factor of 2, e. g. 100, 48, 28, 14, 8, etc. The amount passing a given sieve and retained on the next smaller should be about 1.25 times that retained on next smaller size. For good results brick must have the right range of absorption and a proper surface to bond well with mortar. Cement and lime used in mortar must be (1) suitably plastic to work well under the trowel, (2) adhere very tightly to brick, (3) be sufficiently flexible to take up buffets of wind even in tower buildings, (4) be watertight and (5) be reasonable in price.—G. M. WILLIAMS

Recent improvements in making concrete. H. A. LA RUE. *Canadian Eng.*, Jan. 20, 1931, V. 60, No. 3, p. 16.—Basic idea underlying most methods of proportioning concrete is that a dense mixture of cement, sand and stone is necessary and that the denser the mixture, the stronger the resulting concrete that is obtained. Various methods are employed in the attempt to attain this maximum density. The so-called void method involves the use of enough cement to fill the voids in the sand to make a mortar and then sufficient mortar to fill the voids in the stone. The amount of cement is usually in excess of that required to fill voids in the sand. The method of mechanical analysis involves a sieve analysis of the aggregate and the addition or elimination of certain sized materials so grading of aggregate will conform to an established grading curve. Account must be taken of the fact that the volume of fine aggregate is influenced by its water content so that to insure the proper amount of this size of material account must be taken of bulking due to presence of moisture which will alter its apparent volume. To produce more uniform concrete it has been established that aggregate quantities should be weighed rather than measured by volume. It is of greatest importance in obtaining high strength concrete to keep the mixing water to the minimum necessary to furnish a workable mix. Sufficient water must be used to result in a plastic workable mix but this necessary amount should not be exceeded.—G. M. WILLIAMS

Action of aggressive waters on concrete. HUGO VIERHELLER. *Bautenschutz* (Germany), 1930, V. 1, No. 2, p. 33-7.—Corrosive action of aggressive waters on concrete may be either chemical, chemical and physical or only physical in nature. These factors must be considered when a concrete is judged

for its suitability for certain purposes. In the first case substances, which are dissolved in water, react with cement portion of concrete and either dissolve or weaken such portions thus changing structure and strength of concrete. Agents, which act in this manner are inorganic acids, some organic acids and acid salts. Protective coatings or drainage of water are advisable. Example for second case is crystallization of new compounds formed by chemical reactions in interior of concrete with considerable increase of volume. Latter fact destroys interior structure and leads to softening of concrete. Pure physical action of water on concrete can be found in cases where water is taken up by capillary action and this water generates osmotic or crystallization pressure. This process can appear without any chemical reaction and takes place in concrete of improper density. Structures only partly immersed in water are most likely to be affected in this way. Action of frost falls in this class. Making of dense concrete with sufficient impermeability is chief preventive measure. Directions are given for systematic investigation of different cements and concrete mixtures and of their stability in corrosive waters.—A. E. BEITLICH

Resistance of concrete pipes to corrosion by water. J. O. ROOS AF HJELMASTER. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—The paper comprises the investigation of typical cases of concrete pipe disintegration in Sweden, laboratory tests of the action of water with aggressive carbon dioxide on concrete pipes of different composition, and the application of a new laboratory method for the determination of the dissolving action of different kinds of water percolating through various kinds of cement.—EDITORS N. I. A. T. M.

Variations of the compressive strength of concrete within the water-cement ratio law. IRA L. COLLIER. *Proc. A. S. T. M.*, 1930, Part 2, V. 30, p. 731-741.—Three different series of tests, covering 450 specimens, were performed to determine how strength of concrete is affected by variation in consistency of mix, and in proportion and grading of sand. Water-cement ratio was varied from 0.6 to 1.4, slump from 1 to 9 in., and percentage of sand from 20 to 80. The cylinders were all tested at 7 days. The tests demonstrated that if water-cement ratio of concrete is held constant, and sand and gravel are in the usual proportions of 1:2, the compressive strength decreases as the slump increases, and decreases as the fineness modulus of sand is increased.—GLENN MURPHY

Mortars and concretes of mixed cements. F. FERRARI. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—The object of this study is to demonstrate relationship between the mechanical (crushing) strength of standard mortar and of concrete of determined composition. Mortars and concretes having as a basis binary hydraulic mixtures (portland cement with other substances, pozzuolanic or inert), possess, at same age, very different strengths, depending principally upon nature and percentage of material added to portland cement.—EDITORS N. I. A. T. M.

Volume change of concrete. C. H. SCHOLER AND E. R. DAWLEY. *Proc. A. S. T. M.*, 1930, Part 2, V. 30, p. 751-766.—This paper treats initial expansion or contraction of concrete during hardening period as well as volume changes after specimen has hardened. Changes in length were measured by an optical comparator consisting of two parallel microscopes. The distance between them was determined by an interferometer reading to 0.00005 in. Readings were taken on pieces of glass tubing inserted in the specimens 20 in. apart. In order to reduce pressure of forms against concrete during setting period, forms were lined with soft rubber slabs. It was found that leaky forms caused a rapid shrinkage until set. This was followed by an expansion for about 24 hr., and then a slow, steady shrinkage for an indefinite period. A water-tight form will eliminate the first shrinkage. It was found that character

of aggregate had practically no influence on volume change. Lean mixes showed slightly less change than rich mixes. Mixes studied were more nearly like pavement concrete than like that used in reinforced building construction. Probably the latter would show the greater shrinkage.—GLENN MURPHY

The elastic behavior of concrete—Uber das elastiche Verhalten von Beton. HIROHIKO YOSHIDA. Verlag von Julius Springer, Berlin, 1930, 114 p.—Work was carried out under direction of E. Probst, Technischen Hochschule, Karlsruhe. Methods are given for determining Poisson's ratio for different types of concrete under static loading, as well as effect of various factors such as changes in stress, age of concrete, water cement ratio, mix, etc. The second part deals with the results of a study of application of frequently repeated load, and gives effect of repeated loads on elastic properties. The last section takes up the elastic behavior of concrete and covers elastic afterworking, elastic potential, and a study of velocity of propagation of load waves in concrete. Conclusions of the author include: (1) The value of μ (Poisson's ratio) for concrete decreases with increase in tension. (2) μ for concrete 1:6 mix under a tension between 142.5 to 570 lb. per sq. in. and 142.5 to 712.5 lb. per sq. in. is about 7. With a 1:10 mix μ for the same tension is about 5.5 to 6. (3) The value of μ increases with repeated load. (4) The relation between value of μ, and the tension, and also the relation between the elastic modulus and tension change with repeated load. (5) The elastic behavior with repeated load is related to the afore mentioned change.—H. G. FISK

Investigation into the strength of mortar and concrete for use in large structures and for the manufacture of cement products. O. GRAF. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—The knowledge requisite for the production of mortar and concrete possessing the greatest resistance to crushing, bending and wear, with great impermeability and the minimum shrinkage and expansion, is, for practical purposes, capable of simple expression. The paper is developed on these lines, while in addition, the factors requiring attention in measuring and working the ingredients are briefly dealt with.—EDITORS N. I. A. T. M.

Cement, concrete and reinforced concrete. Laboratory tests, and control and practice on the building site. A. HASCH. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—An attempt is made to deal briefly, from the present day standpoint, with the relative merits of ordinary and high-strength mortars and concrete, as well as with the tests to which these materials should be subjected in the laboratory and on the building site. The essential point is the organization of control tests on the site, combined with an extension of the laboratory tests, especially on the chemical side, since samples taken before the commencement of building operations have not the slightest value. Reference is made to the statistic (theory of probability) treatment of the results of static tests.—EDITORS N. I. A. T. M.

Flow of concrete under sustained compressive stress. R. E. DAVIS AND H. E. DAVIS. *Proc. A. S. T. M.*, 1930, Part 2, V. 30, p. 707-730.—Data are presented from seven series of tests, starting in 1925, and dealing with 215 specimens. The tests were designed to show how time-flow is influenced by richness of mix, water-cement ratio, character and gradation of aggregate, age at time of loading, magnitude of stress, variation in moisture conditions, length of period of sustained stress, reinforcement, and intermittent loading. In addition, the effects of flow upon strength and modulus of elasticity are studied. Aside from earlier tests, flow was measured over a 10 in. gage length. It was found that rate of flow decreases as time increases. Amount of flow was greater for concretes of a lean mix, with high water-cement ratio, containing aggregates with a small fineness modulus. A high applied stress and air storage also increased flow. Rate of unit stress to total unit deformation was decreased by early loading and air storage, and decreased at a decreasing rate

with increase in time. Sandstone and basalt concretes showed greatest flow, and limestone concrete the least. Quartz, granite, and gravel concretes gave intermediate values. The flow for reinforced specimens was much less as the steel took most of load. Effect of cyclic repetition of stress upon flow is not unlike that for steady loading. The modulus of elasticity of concrete which has been subjected to a sustained stress is higher than that for same quality of concrete not previously stressed. Apparently the compressive strength is not affected. Modulus of elasticity at time of loading is not a criterion of flow.—GLENN MURPHY

Research on the variation of the modulus of elasticity under compression with the composition, fluidity, age and strength of concrete. R. DUTRON. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—Modulus of elasticity of concrete, E, is a function of strength, i. e., it depends implicitly on all factors which affect strength: Proportion of cement, nature and grading of inert material, fluidity, and age of the concrete. Value of E may be determined as a function of the crushing strength R of concrete by formula $E = KR^m$; E corresponds to the deformation of concrete under a load equal to three-tenths its breaking load under compression, K and m are two constants which assume different values on the one hand for concrete containing ballast and powdered materials, and on other, for all concretes containing sand.—EDITORS N. I. A. T. M.

The compactness of concrete and its resistance to chemical action. A. POULSEN. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—Even the best concrete is destroyed by the reaction of its free lime with the magnesium sulphate contained in sea water. On the other hand, rich mixtures soon show cracks of their own accord. The application of a protective coating to large masses of concrete employed in marine work is, of course, impossible. To neutralize the excess lime it is necessary to add to the cement, pozzuolana containing in sufficient quantity the necessary hydraulic constituents (e. g. SiO_2 soluble in alkalis). The cement with hydraulic admixtures thus obtained should be submitted to laboratory tests. In Denmark, the Danish diatomaceous earth, Mo Ler, which contains about 60 per cent of soluble SiO_2, has been used with considerable success for the past 20 years.—EDITORS N. I. A. T. M.

Method of disintegrating hardened concrete for the determination of the original ingredients. R. LOMAN. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—The object of the work was discovery of a method of determining original ingredients of hardened concrete. It is possible to disintegrate the concrete satisfactorily without smashing up the aggregate. This is done by heating for a time to 800-900 deg. C., and then cooling by suddenly quenching in water. Aggregate is separated from cement and can be sieved; it is almost completely recovered, but has generally become a little finer, owing to ignition and embrittlement on quenching. This increase in fineness is revealed by sieving. Proportion of cement can be estimated by various methods. Experiment has proved, however, that most rapid method, and that which gives most reliable results, consists in heating to 800-900 deg. C., (which removes combined water and carbon dioxide), and then cooling in a space free from water vapor and CO_2. Weight obtained is that of original cement, less its loss on ignition. The method is of ample accuracy for technical work.—EDITORS N. I. A. T. M.

Further studies on the workability of concrete. W. F. PURRINGTON AND H. C. LORING. *Proc. A. S. T. M.*, 1930, Part 2, V. 30, p. 654-667.—This paper is a continuation of a previous investigation of workability of concrete mixtures by measuring power consumed in mixing concrete. Tests were run with a 390 lb. charge in a vertical-axis type mixer at speeds of 24, 30, 35, and 44 r. p. m. Readings were taken 5 min. after water was added. Actual power

consumption was measured by a prony brake. Mixes were designed for 2,000, 3,000, and 4,000 lb. per sq. in. at 28 days. Data tend to show there is an optimum water-cement ratio at which maximum workability of a concrete is obtained. Above and below this ratio a concrete is produced which tends to increase power consumption due in one case to stickiness of particles, and in other to friction of under-lubricated grains. Different brands of cements do not show consistent relations to power consumption when studied over a long period of time. The addition of calcium chloride affects the workability of different cements differently.—GLENN MURPHY

Strength and resistance to sulfate waters of concrete cured in water vapor at temperatures between 100 and 350 deg. F. DALTON G. MILLER. *Proc. A. S. T. M.*, 1930, Part 2, V. 30, p. 636-653.—In order to approximate the thickness of the wall in drain tile used in the public ditches in the Middle West, 2 by 4-in. cylinders were used in this investigation. Although small, the cylinders were essentially concrete, and not mortar. No aggregate exceeded ⅜ in. in size. The mix was 1:3, and the water-cement ratio varied from 0.59 to 0.64. After curing with steam, some specimens were exposed to alkaline waters of Medicine Lake, S. D. Ultimate compressive strengths were obtained at 7 and 28 days, and 1, 3, and 5 years. The cylinders cured continuously in water averaged from 0.5 to 1.3 per cent less absorption than cylinders cured in water vapor. For identical curing periods, the absorption was nearly constant regardless of temperature. Concrete cured in water vapor between 100 and 285 deg. F. and stored in water continues to increase in strength at a rate not greatly different from control cylinders cured in water. Photomicrographs show that steam curing produces more complete hydration. No strength is gained by curing in steam at temperatures above 155 deg. F., or by curing more than 48 hours. Resistance to sulfate waters is definitely increased by curing temperatures from 212 to 285 deg. F., and for periods up to 6 days.—GLENN MURPHY

Deterioration of concrete in hydraulic structures. A. EKWALL. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—Inspections 10 years ago of hydraulic structures in Sweden displayed some defects in the concrete. Continued observations proved, that concrete in some cases was subject to an increasing deterioration, apparently due to qualities of concrete materials, to methods of making concrete or to conditions to which concrete was exposed. Investigations were arranged with the aim to ascertaining causes of such increasing deterioration. It had been observed that deterioration occurred only in structures exposed to water on one side and was caused by the solubility of lime and decomposition of other chemical combinations in hydrated cement. Particular attention was therefore placed on solubility of cement and aggressiveness of the water. In combination with investigation relating to these factors, practical experiments have been made with concrete slabs exposed to low water pressure during several years. It was proved that Swedish natural waters need not be considered aggressive in this respect. The importance of using sand, relatively free from organic substances, was impressively established. Leaner mixtures than 1:4½ should not be used for concrete exposed to water pressure from one side. Replacing cement by an admixture of 10 per cent lime or 5 per cent calcium chloride improved the watertightness, while 25 per cent trass or slate powder practically gave no improvement.—EDITORS N. I. A. T. M.

Resistance of concrete to chemical attack. K. MANDL. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—In Austria the deterioration of concrete due to injurious influences is relatively slight. The most prominent instance is the destruction of a pillar of a new dwelling house in Vienna, which was definitely found to be due to the action of gypsum. It is especially noteworthy that this damage was not due to sulphate-containing

ground-water, but to surface water that had percolated through the slag-containing fundamental layer, from which it dissolved the sulphate, being then compelled to pass through the concrete pillar, because the slag deposit was laid on material impermeable to water. Several cases of deterioration of the sewer system of Vienna by sulphate-containing water are also reported. A statement is made regarding an investigation into the action of nitrites on concrete, the results of which have been in part already published. It is not yet, however, possible to draw conclusions from this work.—EDITORS N. I. A. T. M.

Designing concrete for high strength, low permeability and low shrinkage. W. A. SLATER. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930.—High strength and low permeability depend primarily upon using the lowest possible water-cement ratio consistent with securing workability of the mix. Designing concrete for a given strength and low permeability reduces to combining water and cement in predetermined proportions with aggregates in such proportions as to give workable mixes and low cost of finished concrete. Most important requisite for low shrinkage appears to be low cement content. However, excessive shrinkage has resulted from the use of trap rock or conglomerate screenings as aggregate in mortar or from the addition of integral waterproofing compounds. Moist curing is an effective measure for promoting high strength, low permeability, and low shrinkage.—EDITORS N. I. A. T. M.

The properties of cement-sawdust mortars, plain, and with various admixtures. S. H. GRAF AND R. H. JOHNSON. *Bull. No. 3*, Engineering Experiment Station, Oregon State College, Sept., 1930.—Investigation covering practicability of using sawdust in portland cement mortar includes effect of incorporating sand and certain other materials into the mixtures. From a consideration of the use for which this material may be employed, the more important properties are compressive and tensile strengths and thermal conductivity. From tests on these points and also on resistance of material to certain corrosive agents, and from noting relationships existing between the foregoing properties and the presence of bark, the water-cement ratio, the specific gravity, and the age of the sawdust, the following conclusions are indicated: (1) Safe strengths may be obtained from cement-sawdust mixtures. If bark-free sawdust is used there is a small but distinct improvement in strength. (2) Addition of sand has but little effect on the strength and is detrimental where light weight and the lowest thermal conductivity are important. (3) Ratio, by volume, of total water to cement is fair index of strength. (4) Addition of 1 per cent by weight of powdered diatomaceous earth is of decided advantage. (5) Resistance to corrosion of cement-sawdust compares favorably with that of ordinary concrete. (6) Sawdust which has been exposed to weather for a comparatively short time may be used without material loss in strength. (7) Cement-sawdust material is a better thermal insulator than ordinary concrete but does not have as high strength. (8) In order to obtain adequate strength in the cement-sawdust material, it is necessary to use such a rich mixture (large cement content) that the cost, in spite of the cheapness of sawdust, will be greater than that of ordinary concrete. (9) Special care must be taken in control of amount of mixing water and in placing and curing cement-sawdust material if sound durable product is to be obtained. (10) In any given case, the desirability of using the sawdust-cement material in preference to ordinary concrete will depend on the value placed on light weight and on low thermal conductivity.—IRA L. COLLIER

High quality aggregates and value of concrete. (See MATERIALS—AGGREGATES.)

Acceptance and control tests for cements. (See MATERIALS—CEMENT.)

Impermeability and permanence of cements. (See MATERIALS—CEMENT.)

Special and fused cements—two Swedish products. (See MATERIALS—CEMENT.)

The Ibis bridge at Vesinet. (See ENGINEERING DESIGN—BRIDGES.)

ENGINEERING DESIGN

BRIDGES

Design of a reinforced concrete skew arch. BERNARD L. WEINER. *Proc. Am. Soc. C. E.*, Jan., 1931, V. 57, No. 1, p. 3-112.—The paper includes: (a) A stress analysis based upon the Rathbun method; (b) Theory of proportioning sections; (c) Short-cut for computation of crown stresses in a symmetrical skew "rigid frame" with hinged ends. A numerical example is provided in each instance. Complete derivations of formulas are given for several cases. It is assumed that readers have a working knowledge of the design of a right arch by standard methods.—H. J. GILKEY

North Bathurst street bridge, Toronto. W. D. PROCTOR. *Canadian Eng.*, Dec. 30, 1930, V. 59, No. 27, p. 745.—Steel girder bridge with concrete deck and piers has been completed at a cost of $250,000. Piers consist of four columns 5 ft. by 3 ft. under the cap resting on reinforced concrete footings 17 ft. by 51 ft. which in turn are supported by Westinghouse centrifugal spun reinforced concrete piles jetted into a sandy sub-soil. Concrete deck is carried on four rows of plate girders spaced 14½ ft. o. c. Distance between curbs is 46 ft. with two 6-ft. sidewalks outside. Concrete deck is carried on transverse concrete beams resting on tops of girders and cantilevered out to support sidewalks. Tests of concrete during progress of work showed strengths in excess of 2000 lbs. specified for slabs, piers and abutments and in excess of 1500 lbs. specified for footings.—G. M. WILLIAMS

Design of Box Culverts. G. H. HARGREAVES. *Concrete Constr. Eng.* (England), Jan., 1931, V. 26, No. 1, p. 21-34.—First consideration is that of loadings and resulting bending moments at ends and center of members. Distribution of pressure on base is assumed uniform. Other loads considered are point loads due to wheel loads on the top slab, triangular and uniform loads on side slabs and uniform loads on top slab. Maximum corner moments occur when horizontal slabs are subjected to their maximum loads. Calculation of moments at ends of slabs of a box culvert are simplified by use of diagrams. Bending moments are first expressed in terms of a constant F multiplied by a function of the load on the member and width or height of culvert. Diagrams are given for each type of loading mentioned. The values of the constant F for a selected ratio of moment of inertia of top and side slabs are obtained from the diagrams for ratio of height to width used. Moments thus obtained for different types of loading (a diagram is given for each loading) are then correctly combined to obtain maximum moments. Diagrams are given from which the coefficient F can be obtained for: uniform distribution of load on the base slab combined with concentrated loads on the top slab; uniform distributed load on top and bottom slabs; uniform side loads; triangular side loads. Maximum stresses may be determined in usual way neglecting effect of direct thrust. An illustration shows typical arrangement of main steel. Calculations are given for maximum moments in a box culvert of known dimensions and assumed loads.—JOSEPH MARIN

The Ibis bridge at Vesinet (Seine-et-Oise). A. MESNAGER, F. BARTHES, J. VEYRIER. *Genie Civil*, Jan. 17, 1931, V. 98, No. 3, p. 61-65.—A footbridge rebuilt for automobile traffic presented the difficulty of a minimum clearance

above water level of 6.2 ft. in a 29.5-ft. arch span. A rise of 9.8 in. in 14.1 ft. permitted all vehicles to pass. Novel features of the bridge were steel pipes filled with concrete, which constituted the arch. This "integral reinforcement" offers better resistance to transverse expansion of concrete due to longitudinal compression. Tests of concrete surrounded by a shell of steel were made in 1915 by Rabut at the Testing Laboratory of the École des Ponts et Chaussées and by Professor Baes of Brussels, Belgium, reporting at a convention in Vienna in 1928. Messrs. Mesnager and Veyrier patented an adjustable end connection (a screw stopper) eliminating all danger of loss of strength in tubular reinforcement by contraction. At the beginning of 1930 tests made by the Laboratory of the City of Paris on tubular steel specimens filled with concrete, yielded results resembling those of a theoretical homogeneous specimen, whose Young's modulus, elastic limit and compression strength lie half way between those of steel and concrete. An allowable stress of 2845 lb. per sq. in. is admissible over the entire section, when the ratio of steel to gross section is 0.09 and the weight of steel is 1115 lb. per cu. yd. of total volume. In accordance with the steel ratio, the allowable stress used in the design of bridge was 4980 lb. per sq. in. Anchorage of tubular reinforcement is designed with great care. In filling the shells with concrete, pneumatic hammers produced vibration in the mass leaving the hopper. Concrete mix was proportioned as follows: 1.05 cu. yd. gravel (passing mesh with .39 in. diameter opening); .51 cu. yd. river sand; 880-lb. of Supercilor (special) cement and 31.2-gal. of water. (Supercilor cement requires considerably more water than ordinary cement.) The strength varied with the type of mold used for the specimen, being an average of 4550 lb. per sq. in. for screwed molds and only 2700 lb. per sq. in. for nailed molds, due to a defect. The tensile strengths were 597 and 234 lb. per sq. in. respectively for the two types of molds. Bridge was tested on August 12, 1930, with uniformly distributed load of 815 lb. per sq. ft. and a 10-ton roller.—M. A. CORBIN

Testing concrete bridges. C. S. CHETTOE. *Concrete Constr. Eng.* (England), Jan., 1931, V. 26, No. 1, p. 5-8.—Reasons are given why the deflection tests of concrete bridges should not be the same as for steel bridges (namely a deflection limit of 1/1600 of the span length as the maximum deflection). Loading and deflection tests for concrete bridges should be made at least one year after the completion of the bridge for following reasons: (1) Concrete gains strength with time and the working stresses for concrete are generally based on strength at 90 days. (2) Temperature stresses are more important in concrete bridges than in steel bridges. (3) Cracks that would not otherwise appear, may be produced by deflection tests made before 90-day period. (4) Most of shrinkage of concrete occurs during 90-day period. The particular effects produced in different types of bridges are discussed. In beam and slab bridges temperature changes and resulting stress in the steel may be worth consideration, though effect on concrete is negligible. Shrinkage and plastic effects are discussed. Temperature and other factors in frame bridges are in general slightly more pronounced than in slab or beam bridges. In fixed and two-pin arches the dead load and shrinkage stresses alone will produce plastic yield, as those due to live load will only be applied for short periods and those due to temperature will be subject to reversal. Temperature and shrinkage stresses become of greater importance the flatter the arch. Three-pin arches, if pin friction be neglected, are unaffected by temperature and shrinkage, and are only subjected to local effects of plastic yield. It is evident that almost all concrete bridges vary periodically in strength due to temperature changes, and that they are subject to a progressive strengthening due to the gradual increase in the strength of concrete. Secondary effects due to plastic yield in general, relieve concrete of some stress as time goes on. Usually shrinkage will have little influence after three months. In conclusion, concrete bridge should not be subjected to loading and deflection tests at its completion but tests should be made at least one year after the completion.—JOSEPH MARIN

The International contest for the Dreirosen bridge in Basel (Switzerland). LEOPOLD BERGER. *Zement* (Germany), Jan. 15, 1931, V. 20, No. 3, p. 59-61.—Designs and costs of proposed structures of steel and reinforced concrete for the Dreirosen bridge over river Rhine in Basel are discussed. Designs were asked for bridge with one or three openings, center opening being at least 328 ft. wide. Costs for reinforced concrete bridges are in general only 9 per cent higher than prices of steel structures.—A. E. BEITLICH

A method of arch design. G. P. MANNING. *Concrete Constr. Eng.* (England), Feb., 1931, V. 26, No. 2, p. 129-141.—To estimate dead load and temperature stresses in an arch without a number of approximations, it is well to calculate beforehand the approximate area required at crown section. It is also useful to know saving effected by using richer mix of concrete and, for an open spandrel arch, best ratio of breadth to depth for the ribs. To obtain uniformity of elastic properties under varying stresses, examination of strength of cross sections under combined bending moment and thrust shows that about 1 per cent steel top and bottom is good assumption. For preliminary investigation it is sufficiently close to assume stress $= \frac{thrust}{area} \pm \frac{moment}{modulus}$ for the case where tension occurs. Example is given of parabolic arch of 150-ft. span and 30 ft. rise. Curves given show relation between approximated temperature stresses (including temperature crown drop stresses) and thickness expressed as a ratio of length. These curves are given for different ratios of rise to span length for both the extrados and intrados and for a rise or fall in temperature of 30 deg. F. Stresses calculated from relation expressed above. Calculations show that temperature stresses are almost independent of the arch profile and practically independent of area of reinforcement (since increase in steel increases moment of inertia in same proportion). For selected arch a diagram shows relation between approximate dead load stresses at crown for uniform dead load and thickness at crown expressed as a ratio of the span length. Curves are given for both the extrados and intrados and for different ratios of rise to span. Increasing the reinforcement from 2 to 4 per cent reduces the stresses about 20 per cent. Similiar approximate curves for stresses at crown section are given for stresses due to a spandrel load. Increasing the reinforcement from 2 to 4 per cent decreases the stresses about 20 per cent. Stresses due to live load are obtained by using the influence line to first obtain values of moment and thrust for crown section. Corresponding crown-drop stresses are readily found from diagram similiar to temperature stresses. Increasing reinforcement from 2 to 4 per cent reduces live load stresses about 20 per cent. Examples apply above diagrams to find thickness at crown of filled-spandrel and open-spandrel arches of given span and rise. The section required is determined for different allowable unit stresses and most economical mix of concrete thus determined.—JOSEPH MARIN

BUILDINGS

The Ford factory at Dagenham. *Concrete Constr. Eng.* (England), Jan., 1931, V. 26, No. 1, p. 8-19.—In factory which will eventually be largest motor car factory in Europe, main block of office buildings is to be 200 ft. long by 50 ft. wide. Three main buildings comprise the foundry and machine shop, the manufacturing building and the assembly shop. A reinforced concrete tunnel 8 ft. 6 in. high and 12 ft. 6 in. wide extends for more than 1000 ft. and carries the power, heating, oil, lighting, and water service mains. Ultimately two blast furnaces of a 24-hour nominal capacity of 500 tons will be in operation. There are to be 45 coke ovens capable of carbonizing 800 tons of coal in 24 hours. A 30,000 k. w. turbine running at 3,000 r. p. m. will be installed in new power house. An important unit is the ore yard for storage and handling of the coal, iron ore and limestone. Work done during the past sixteen months

includes: excavation, 500,000 cu. yd.; piles driven, 13,000; steel work erected, 5,500 tons; reinforced concrete laid, 150,000 sq. yd.; length of railway track laid, 3½ miles; bridges constructed, 2; length of roads constructed on embankments, 1½ miles.—JOSEPH MARIN

DAMS

Third power development in Stave-Alouette group. *Contract Record Eng. Rev.*, Nov. 26, 1930, V. 44, No. 48, p. 1471.—Ruskin hydro-electric power plant of the British Columbia Electric Railway Co., consists of concrete lined tunnels, steel framed power house clothed with concrete and concrete dam of overflow type. Tunnels are 24 ft. in diameter through solid rock and lined with concrete. Dam is of the gravity type 400 ft. long on the crest with a total height of 185 ft., surmounted by concrete piers carrying a roadway, with the openings between piers closed by Tainter gates 33 ft. wide and 26 ft. high.—G. M. WILLIAMS

Construction of Ruskin power project. C. E. BLEE. *Canadian Eng.*, Jan. 13, 1931, V. 60, No. 2, p. 13.—British Columbia Power Corporation, Ltd., has recently completed a power development on Stave River near Ruskin, B. C., including concrete diversion dam of overflow, gravity type, straight in plan with a crest length of 195 ft. and height of 195 ft. above lowest foundation point. On spillway crest piers are 40 ft. o. c. carrying a roadway with Taintor gates 33 ft. by 26 ft. installed between piers to regulate discharge. Dam is designed to have resultant pressure fall within middle third with reservoir full with uplift varying from 50 per cent head at upstream face to 25 per cent at plane of drainage system, and zero at the downstream toe. Total concrete in dam is 105,000 cu. yd. Field mix for body of dam was 1 cement, 3.05 sand, 2.69 gravel (3 in. to 6 in.) which gave about 2,000 lb. per sq. in. at 28 days. Concrete weighed 155.6 lb. per cu. ft. Cement requirement was approximately 1 Canadian barrel per cu. yd.—G. M. WILLIAMS

Some new ideas on dams. EDWARD GODFREY. *Struct. Eng.* (England), Jan., 1931, V. 9, No. 1, p. 11-17.—Practically every failure of a dam, whether of masonry, concrete, or earth, can be explained by underpressure and neglect to provide for underpressure in design. Underpressure at present is rarely emphasized. Only possible reduction of underpressure, assuming either the thinnest fissure, saturated sand or saturated earth beneath a dam, is reduction due to escape of water. For a dam founded on solid rock the possibility for entrance of water, and consequently safety of the structure, depends upon perfection of construction. Escape of water below dam is usually prevented by plugging leaks, thus causing water under dam to accumulate its full head. Where a dam fails by underpressure it may be a sliding failure due to lubricated bottom. Erosion of soil may also follow underpressure. Failures of St. Francis dam in California, Gleno dam in Italy, and Lafayette earth dam in California are explained by consideration of underpressure. Various other illustrations of failures are cited as evidence of the points raised.—V. P. JENSEN

Recent advances in buttress-type dams. CALVIN V. DAVIS. *Civil Engineering*, Feb., 1931, V. 1, No. 5, p. 387-391.—As a result of recent advances in structural design, two distinct types of buttress dams have been developed, characterized respectively by massive buttresses and by thin buttresses. Principal characteristics of thin buttress type are use of minimum buttress thicknesses and spacings, and placing of greater dependence on stabilizing effect of water load on deck than in massive buttress type. Very low sliding factors may be obtained making dam suitable for almost any type of foundation. On soft foundations, limiting feature is span of slab footing between buttresses. Better foundation design is obtained by keeping buttresses

relatively close together thus necessitating thin buttress design. Economy may be obtained by use of massive buttress type with good foundations. New design with round-head buttresses has following advantages: (1) Water loads transmitted in direct compression to buttress through massive cylindrical portion. Radial water bearing face, to which all pressures are normal, eliminates bending and diagonal tension in upstream portion. (2) Shape of buttress gives almost ideal distribution of principal stresses and shear throughout dam. (3) All members are massive and solid. Volume of concrete in massive buttress type is about one-third of that in gravity type, in which governing feature is safety against overturning. Reduction in cost of massive buttress type over gravity type is about 50 per cent for dam 300 ft. high. Aside from development of two types mentioned, most noteworthy advances in design and construction have been improved methods of stress analysis and development of system of buttress construction and contraction joints. Modern methods of stress analysis were introduced in this country 20 years ago by Professor Cain and have been recently adapted to design of buttress-type dams. A more thorough knowledge of stress distribution has been directly responsible for development of improved system for placing construction joints in high buttresses. In laying out system of joints for buttress it is desirable to retain monolithic action of buttress as a whole and to place joints so there will be no tendency for relative movement of buttress sections separated by joint.—D. E. LARSON

MISCELLANEOUS

Discs and disc sectors. *Ostr. Bauzeitung* (Austria), Dec. 20, 1930, V. 6, No. 51, p. 819-22.—Mathematical formulas are given which illustrate nature of discs and disc sections and their importance in static calculations of structures. (cf. *Ostr. Bauzeitung* (Austria), 1930, V. 6, No. 20 and 40.)—A. E. BEITLICH

Introduction to calculations of frame structures. *Ostr. Bauzeitung* (Austria), Dec. 27, 1930, V. 6, No. 52, p. 836-42.—Many tables are used to explain fundamental principles of calculations of structural members. Subjects of discussion are: degree of indetermination of structural members, laws of symmetrical loads, deformation of simple frames and deformation under consideration of torsion and bending effects.—A. E. BEITLICH

Harbor enlargements in Boulogne sur mer (France). BOLLE. *Bautechnik* (Germany), Oct. 3, 1930, V. 8, No. 43, p. 658.—Extensive construction program for enlarging existing harbor structures includes breakwater 1.24 miles long, extension of another breakwater about 2300 ft., excavation of harbor entrance and western part of harbor to a depth of 42.7 ft., quay for passenger service which will be 984 ft. wide, construction of railway station and dock 2300 ft. long.—A. E. BEITLICH

Structural tests on models by Begg's method. J. BLAZEK. *Summary Reports*, First International Congress for Concrete and Reinforced Concrete, Liege, 1930.—The author considers the relative advantages and disadvantages of various methods of solving problems in statics by tests made on models; in particular the following: (1) The method of exact reproduction on a reduced scale. (2) The method of photoelastic measurement. (3) The Nupubest method. (4) The Continostat method. (5) Begg's method. The author finally reaches the conclusion that Begg's method is most suitable in practice, provided the accessories are well adapted to their purpose.—EDITIONS LA TECHNIQUE DES TRAVAUX

Coefficient $n = \frac{E_s}{E_c}$ and allowable stresses for concrete and steel in reinforced concrete. M. ROS. *Reports*, First International Congress for

Concrete and Reinforced Concrete, Liege, 1930.—Value of n is not fixed by uniform methods in specifications used in different countries but varies from 5 to 20. Value of maximum compression in concrete as calculated differs from value obtained using n. Hence, following points were investigated: Actual properties of portland cement, increased strength of concrete, values of maximum stresses corresponding to change in value of E_c. Influence of change in value of n on stress in concrete was studied—for stress in steel of 14,250 lb. per sq. in. and 1 per cent steel, maximum compression for concrete = 1050 lb. per sq. in. for $n = 5$, and 615 lb. per sq. in. for $n = 20$. Study was next made of actual values of n for: (1) Flexure—Value of n depends upon the loading. Let M_a = the external moment, M_i = internal calculated moment. Assuming Hookes Law and neglecting tension in concrete, maximum compression in concrete $= \frac{2M_a}{x(h-x/3)}$ and the maximum tension in the steel $= \frac{M_a}{J_c(h-x/3)}$, where x = the distance from outer fibre in compression to neutral axis and h = depth of beam. But x is a function of n therefore $x = nf_c\left(\sqrt{1+\frac{2h}{nf_c}}\right)-1$, where f_c = stress in steel. Values of maximum stresses are thus dependent upon value of n. From stress-strain curves of concrete and steel, stresses for a given section of beam for known load and percentage of reinforcement can be obtained. Internal moment can be calculated assuming plane sections remain plane. With above relations actual values of n can be obtained, using stress-strain curves. Choosing arbitrary values of n the values of stresses in steel and concrete can be calculated for given load. These can then be compared with actual corresponding values of stresses. This method was applied to beam of rectangular section with 1½ per cent steel and subjected to flexure. Results are given by curves, one for each concrete considered for beams with concrete of compressive strength of 2,000, 3,250 and 4,300 lb. per sq. in., with corresponding steel of apparent elastic limit of 38,500, 38,500 and 50,000 lb. per sq. in. respectively. For case 1, n varied from 8.3 to 35 corresponding to stresses in concrete from 0 to 2,000. The calculated compressive strength for $n = 10$ is less than, or equal to allowable compression of 930 lb. per sq. in. For values of stresses greater than allowable there is a difference between actual compressive stress and that calculated for $n = 10$, increasing as stresses become greater. Actual stresses in steel are little different from calculated values, using $n = 10$. For concrete of compressive strength = 3,250 lb. per sq. in., n varied from 6.7 to 13.6. Value of n at failure of beam = 7.2. Good agreement was noted between actual and calculated values of stress in concrete using value of $n = 10$. The ultimate strength as calculated using $n = 10$ and compression in concrete = 3,250 lb. per sq. in. agrees well with the actual value. For concrete of compressive strength = 4,300 lb. per sq. in. n varied from 5.8 to 9.5 corresponding to stress in concrete from 0 to 4,300 lb. per sq. in. Value of n at failure = 6.6. Actual values of compression in concrete are a little higher than those calculated for $n = 10$. For tension in steel, actual values are a little smaller than those calculated for $n = 10$. Strength calculated using $n = 10$ and compression in concrete = 4,300 lb., is a little greater than actual value. At failure by flexure $n = 20$. Actual values of tension in steel are less than calculated values for $n = 10$. (2) Axial compression—Values of n were determined for given load by means of stress-strain curves for three cases, strengths of concrete of 2,000, 3,250 and 4,300 lb. per sq. in. with strength of reinforcing steel of proportional limit = 27,100, 27,100 and 38,500 lb. per sq. in. respectively. For strength of concrete of 3,250 and 4,100 value of n varied from 5 to 12. For these two cases the value of $n = 10$ gives close agreement between calculated and actual values of stresses. For 2,000-lb. concrete, n varies from 8 to 18. Following values are proposed for new Swiss specifications for strength of reinforced concrete, discussed by Swiss Society of Engineers and Architects. (1) Coefficient n is to be taken as 10 for compression and flexure. This value of n gives close agreement between the actual and calcu-

lated values of tension in steel and compression in concrete. (2) For $n = 10$ the values of compression in concrete are 10 to 25 per cent greater than obtained for $n = 15$ or 20. Allowable values are thus increased, corresponding to strengths of concrete cubes in simple compression. (3) Allowable shearing stress is between 57 and 71 lb. per sq. in. Quality of concrete is specified. Allowable values of stress in reinforcing steel is 17,000 and 23,000 lb. per sq. in. for steel whose apparent elastic limit is 39,000 and 50,000 lb. per sq. in. respectively. Allowable stresses in steel and concrete for columns and beams are given.—J. MARIN

Calculation methods. "Bemessungsverfahren." B. LOESER. 1930, Wilhelm Ernst and Son, Berlin (Germany), third edition, R. M. 6.50. Reviewed in *Zement* (Germany), Dec. 4, 1920, V. 19, No. 49, p. 1170.—Book prepared for contractor and designer, explains large number of different calculation methods. Special consideration is given to changes of certain dimensions and the effect of such changes on other structural parts.—A. E. BEITLICH

Reinforced concrete construction. Its theory and application. "Der Eisenbetonbau. Seine Theorie und Anwendung." E. MOERSCH. 1929, Konrad Wittwer, Stuttgart (Germany), V. 1, second part, sixth enlarged edition, 541 pp., 614 illustrations, R. M. 27.00. Reviewed in *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Dec. 19, 1930, V. 82, No. 51-52, p. 439.—Entire theory of reinforced concrete construction is explained based on newest research developments. Numerous experiments aid in explanation of subject.—A. E. BEITLICH

Increasing of strength of steel skeleton structures with concrete encasements. FRITZ EMPERGER. *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Nov. 21, 1930, V. 82, No. 47-48, p. 406-8.—Author discusses results of tests carried out mostly in United States on structural steel encasements. (cf. Morris and Shank, "Gunite and concrete encasement to increase strength of structural steel," 1928, Columbus, O., and reference list, R. Zipprodt, *J. Western Soc. Eng.*, 1929, No. 5.) Great advantages of this type of encasements are illustrated and their economic importance characterized. Number of profiles of steel girders can be reduced. Static calculations of such structures are given. Similar tests are carried out by Prof. Klockner in Prague (Czecho-Slovak Republic).—A. E. BEITLICH

Handbook for reinforced concrete construction. "Handbuch fuer Eisenbetonbau." H. C. EMPERGER. 1930, Wilhelm Ernst and Son, Berlin (Germany), Vol. 1, fourth edition. Reviewed in *Zement* (Germany), Dec. 4, 1930, V. 19, No. 49, p. 1170.—The new edition of Vol. 1 deals with historical development, experiments and theory. Prof. Foerster wrote first chapter. Experiments carried out by Otto Graf are described and widely discussed. Chapters on statics are treated by Prof. Domke. Results of and experiments with different methods are illustrated and relations between theory and practice are described. Numerous references are included.—A. E. BEITLICH

A practical venturi meter for irrigation service. J. E. CHRISTIANSEN AND I. H. TEILMAN. *Eng. News Record*, Jan. 29, 1931, V. 106, No. 5, p. 187-188. A Venturi meter made of precast concrete tube has been developed to eliminate difficulties common to usual devices used to measure irrigation water. About 50 of these meters ranging in size from 16 to 42 in. were placed in service in the Consolidated Irrigation District near Fresno, Calif., during 1929-1930 irrigating season and were found to be practical for actual field use. Meters consist of three sections of precast concrete pipe to form the tube and a vertical well for measuring heads. Beginning at the upstream end, parts of meter consist of: (1) a short entrance section of uniform diameter containing the entrance pressure connections; (2) combined entrance cone and throat sections with piezometer ring, and (3) exit cone of gradual taper providing a

return to original diameter. Sections are cast in heavy sheet metal forms and reinforced with ¼-in. bars. Installation of tube is similar to manner of installing same amount of concrete pipe.—D. E. LARSON

Structural design and construction of concrete improved in 1930. *Concrete*, Feb., 1931, V. 38, No. 2, p. 16-18.—Conviction that high quality in concrete means density as well as strength has spread in past year. Interest is manifested in use of large size aggregates in massive work, particularly dams, mixers using up to 9-in. sizes. Concrete containing large sizes was tamped or puddled by means of electric-driven tampers or vibrators. Most important development in waterproofing is investigation at Bureau of Standards, of 75 commercial products. Railway engineering association developed formulas for design of flat-slab structures under concentrated loadings. Reinforced concrete frames are being built to greater heights, column sizes being reduced by use of cores of structural steel H-beams or cast iron centers. Light-weight aggregates reduce weight of structural frame and floor. Value of continuous belt conveyor on large project demonstrated in construction of dam near Wilmington, Del. Concrete was successfully transported a distance of 1900 ft. from mixer to deposit. Use of and development of equipment for handling of bulk cement is advancing. Revised specifications for placing of terrazzo floors under preparation by terrazzo association. Use of metal forms in building construction evident.—C. BACHMANN

The Nag Hamadi barrage. *Engineering* (England), Jan. 2, 1931, V. 131, No. 3390, p. 20.—The Nag Hamadi barrage, below Luxor in Egypt, the latest of a series of works built across the Nile to increase facilities for irrigation in Upper Egypt, consists of two abutments, nine main piers each 13 ft. 1 in. wide and 90 intermediate piers, 6 ft. 6 in. wide, supported on a concrete foundation approximately 10 ft. thick, of 1:6 portland cement concrete paved with gravel at the sluice openings. Piers are of limestone ashlar with rubble core, the lower portions being faced with dressed granite.—G. M. WILLIAMS

Statics. Part 1. Fundamental principles of statics of rigid body. "Statik. Teil 1. Die Grundlagen der Statik starrer Koerper." FERDINAND SCHLEICHER. 1930, Walter de Gruyter and Comp. Berlin and Leipzig (Germany), 143 p., 47 illustrations, R. M. 1.80. Reviewed in *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Nov. 21, 1930, V. 82, No. 47-48, p. 412.—Chapters of book deal with: introduction, forces with one point of attack, graphic demonstration of forces in the plane, force couple and moment, principle of virtual energy and equilibrium conditions. Extensive reference list is given.—A. E. BEITLICH

Statics of structural members. "Statik der Tragwerke." WALTER KAUFMANN. 1930, Julius Springer, Berlin (Germany), second enlarged edition 322 p., 368 illustrations, R. M. 19.50. Reviewed in *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Dec. 5, 1930, V. 82, No. 49-50, p. 424.—Six chapters of book deal with (1) general fundamental principles; (2) moments, transverse and normal forces in statically determinate structures; (3) determination of tensions in statically determinate structures; (4) elastic deformations; (5) theory of statically indeterminate systems and (6) statically indeterminate structures. Book is a comprehensive treatise of this subject. Method of S. Mueller for solution of general elasticity equations with only one unknown is described.—A. E. BEITLICH

New quays in the harbor of Hamburg (Germany). *Zement* (Germany), Jan. 8, 1931, V. 20, No. 2, p. 39-40.—New quay wall for Rhenania-Ossag Oil Co., in Hamburg was built during winter 1929-30. Reinforced concrete foundation piles are from 39.7 to 45.9 ft. long and 13.4 in. square. Steel sheet pilings of Larrsen type No. 3, which are 38.7 ft. long, were used. Top of wall is faced with granite slabs. Concrete piles are provided with acid repellent coating. Tracks of travelling crane are supported by wall.—A. E. BEITLICH

Stresses and strains in spirally reinforced columns. F. E. RICHART. *First Communications of N. I. A. T. M.* Group B, Zurich, 1930. In studies of concrete subjected to compression in three directions, it was found that the material in a spirally reinforced column obeyed the same laws as a plain concrete cylinder loaded at the ends and subjected to lateral pressure. Determination of pressure exerted by spirals upon the concrete core required accurate knowledge of stress-strain properties of the steel, together with a comprehensive series of strain measurements on the columns. The plastic condition of the concrete of the column core at high loads was well shown by the flow of concrete past the spiral reinforcement and by properties of the concrete alone after it had undergone large deformations.—EDITORS N. I. A. T. M.

ARCHITECTURAL DESIGN

Church construction "Evangelischer Kirchenbau." 1930, Editor: Beratungstelle fuer kirchliche Kunst beim evangelischen Presseverband fuer Rheinland in Essen (Germany). Reviewed in *Zement* (Germany), Dec. 11, 1930, V. 19, No. 50, p. 1192.—Uses of reinforced concrete and steel in modern church construction are illustrated in comprehensive manner and several examples are given. Development of modern church type in Europe is discussed from viewpoint of the architect.—A. E. BEITLICH

St. Nikolai, a church of reinforced concrete and glass. PAUL GIRKON. *Zement* (Germany), Jan. 1, 1931, V. 20, No. 1, p. 1-24.—Principles of construction and architectural design of an outstanding example of modern church are entirely new. Only glass and reinforced concrete were used. Calculation of frames of east room against wind pressure was very difficult. This room is formed by three glass walls, structural members of which are made of reinforced concrete. Only two 12 by 12-in. columns are erected in corners. Tower structure is entirely separated from main building. It is 167.3 ft. high and has box-shaped cross-section, 21.7 ft. wide, walls being 7.9 in. thick. Horizontal girders (31.5 by 7.9 in.) are arranged 29.5 ft. o. c. They separate tower walls into single reinforced concrete panels 21.7 by 29.5 ft. Foundation of tower consists of reinforced concrete ring 6.6 ft. wide and 27.6 in. thick; it is placed 21.3 ft. deep. Greatest part of article is devoted to consideration of architectural design and characterizes suitability of reinforced concrete for such construction purposes, with detailed description of different parts of interior. Arrangements of lights show entirely new features.—A. E. BEITLICH

FIELD CONSTRUCTION

BRIDGES

Three cableways and precast units speed winter bridge construction. B. A. WILDER. *Eng. News Record*, Jan. 8, 1931, V. 105, No. 2, p. 64-65.—Winter Construction on a $300,000 concrete arch road bridge across Androscoggin River in Maine was made more certain by pre-casting the 250 curtain walls. They were placed by means of cableways—a separate one for each of the three arch ribs.—GLENN MURPHY

BUILDINGS

Concrete structural frame climbs three stories per week. CEDRIC WILLSON. *Concrete*, Feb., 1931, V. 38, No. 2, p. 41-42.—Schedule on 15-story concrete frame, Oklahoma building, calling for 3 floors per week, was easily maintained. By getting high early strength from standard portland cement, contractor was able to use two shifts, and maintain time schedule without

trouble or extra expense. All concrete mixtures were designed by strength charts. Three classes of concrete were used, containing 6, 7, and 8 gal. water per sack of cement. Mixes were designed to contain 6½, 5½, and 4¾ sacks of cement per cu. yd. of concrete. Four sets of forms were used, being stripped in 48 and 72 hr. and 7 days. Test cylinders broken at 3, 7, and 28 days showed high strengths.—C. BACHMANN

New system of construction. *Conc. Building Conc. Products* (England), Dec., 1930, V. 5, No. 12, p. 153.—Hollow precast units are used in the system described, for walls, columns, beams and floors, etc., and it is claimed that the system is adapted for rapid construction, architectural treatment without extra cost, and prevention of condensation. It is cheaper than steel or reinforced concrete. For walls units are standardized in sizes for various thicknesses, with grooves at each end for grouting, and vertical cavities. Face is 2 in. thick granite concrete and the rest is clinker concrete. For columns the vertical cavities are reinforced with steel and concrete and these stanchions may be part of the wall or stand out from face. Beams are formed in precast units used as shuttering, and which form a trough into which concrete and steel may be placed. These units may be granite faced for use as external beams. At junctions with columns, holes are made in beam shells to allow the column steel to pass through. Floor slabs are made in 2 ft. by 18 in. by 8½ in. units with two longitudinal cavities. The sides of slab and webs between cavities are 1 in. thick. Steel and concrete may be placed between adjacent slabs thus allowing beams to be formed within the floor construction. A wide range of cast stone units may be used in conjunction with the system for decorative purposes. These are cast in strong wooden frames divided with metal dividers. Wing nuts and bolts through gas barrel are employed to hold the whole rigidly together. Each mould makes 14 blocks and they are erected in tiers, five high. Concrete mixers are fed by materials from overhead bins, charged by elevators from stock piles outside the building.—JOHN E. ADAMS

DAMS

The Don Martin project. ANDREW WEISS. *Proc. Am. Soc. C. E.*, Dec., 1930, V. 56 No. 10, p. 2141-2160.—Don Martin Project, one of the largest constructed under the Mexican Federal Irrigation Law of 1926, is located on the Salado River in the states of Coahuila and Nuevo Leon. The reservoir covers 48,412 acres, will store 1,123,600 acre ft. and will serve 160,000 irrigable acres. The dam (41 miles upstream from Rodriguez) is a composite concrete and earth structure. The overflow (concrete) section is 768 ft. long, is of the round-head buttress type and about 86 ft. high to spillway crest. The aggregate was crushed limestone from the right abutment. Part of the same material was returned through cone crushers to supply the sand. The concrete plant consisted of two 1 cu. yd. mixers located directly below the storage bins. Concrete was conveyed in side-dump cars. The 3231 linear ft. of earth and gravel embankment section was protected by a concrete slab varying from 11 in. at base to 8 in. at crown reinforced with ¾ in. round bars 12 in. o. c. each way.—H. J. GILKEY

Toro Rapids dam. *Contract Record Eng. Rev.*, Dec. 10, 1930, V. 44, No. 5, p. 1517.—The Shawinigan Water and Power Co. has completed an impounding and regulating dam on the Mattawin River in Northern Quebec located 80 miles from a railway. The dam consists of a bulkhead section of gravity type, a sluiceway section and a control gate section. The Toro dam is 90 ft. high, 2400 ft. long at the crest, including 1700 ft. of earthfill and contains 52,000 cu. yd. concrete. Concrete aggregates consisted of sand excavated from below water level and stone quarried and crushed near the dam site. An inundator was used in proportioning and concrete was distributed by means of a tower and cableway.—G. M. WILLIAMS

Foundation procedure at Owyhee Dam. *Eng. News Record*, Jan. 29, 1931, V. 106, No. 5, p. 178-182.—Foundation problems, complicated by the necessity of excavating and concreting a fault zone 190 ft. below streambed, have been solved at the 530-ft. arched-gravity dam being built for the Owyhee project in eastern Oregon, and concrete placing in the main structure is well started. It was necessary to remove 38,000 cu. yd. of material from 250-ft. length of fault zone. This was followed by replacement with concrete. Completion of this work permitted concreting operations on a full scale, and about 1,000 cu. yd. per shift are being placed in the structure from an 8-cu. yd. bucket handled from an overhead cableway. The mix is proportioned to secure finished concrete having economic balance between qualities of strength, impermeability and durability, with due regard for desirability of using all the coarse aggregate brought to the site. Result of this balancing of concrete characteristics is use of 1 bbl. of cement per cu. yd. of concrete in dam. Strength of concrete averages about 3,500 lb. at 28 days, approximately six times maximum stress of 600 lb. used in design and more than double specification requirements of 1,500 lb. Consideration of factors of impermeability and permanence account for maintenance of this cement proportion. Concrete placed within 3 or 4 ft. of the upstream face is enriched by increasing the cement content to 1.25 bbl. per cu. yd.—D. E. LARSON

The Osage hydro-electric project. G. R. STRANDBERG. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 243-248.—Recently completed project will serve as peak-load plant, serving St. Louis by being tied into the Keokuk hydro-plant and steam plants within St. Louis. Bagnell Dam, located 75 miles above confluence of Osage and Missouri rivers about half way between St. Louis and Kansas City, creates only large lake in Missouri and fourth largest artificial lake in United States, the length being 130 miles, capacity 1,200,000 acre feet (with a 30-ft. drawdown), area 95 square miles (61,000 acres), with drainage area above the dam 14,000 square miles. Average river flow is 10,500 c. f. s. fluctuating between 110,000 and 324 c. f. s. Bagnell Dam is of concrete gravity type 2543 ft. long and 148 ft. from bedrock to floor of 20 ft. wide bridge over dam. The water level can be raised about 105 ft. and a full year's flow can be equalized. Foundation rocks are dolomite and sandstone which lie 25 ft. or more below water section. Bottom widths are from 93 to 107 ft. The dam contains about 550,000 cu. yd. of concrete and 875,000 cu. yd. of earth and gravel were excavated. Capacity is initially 180,000 h. p. (6 units) with 2 service units and 2 additional main units of same type. The plant consisted of a 4-mile construction railway from Bagnell and 2 cubic-yard mixers located just downstream from construction bridge. Sand and gravel for concrete were dredged from river bed 3½ miles down stream from dam.—H. J. GILKEY

Construction of Ruskin power project. (See ENGINEERING DESIGN—DAMS.)

MISCELLANEOUS

When to use piling. A. C. EVERHAM. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 304-6.—The usual considerations controlling the use of piles are reviewed and comparisons made between concrete and wooden piles and between straight sided and tapered piles. Soil tests are mentioned and the reader is warned against drawing sweeping conclusions from small-area tests. For foundations under water, pre-cast piles 115 ft. long and 24 x 24 in. in cross-section were driven for a bridge at Newport News. These are longest piles ever driven and special precautions and methods were required to prevent deflection cracks and to secure proper alignment.—H. J. GILKEY

Glass and reinforced concrete (Glaseisenbeton) and its application for large concrete structures. H. CRAEMER. *Zement* (Germany), Dec. 11,

1930, V. 19, No. 50, p. 1185-8.—A new combination of reinforced concrete and glass, called "Rotalith," is described. New construction method used round glass bodies which are placed into forms and imbedded in concrete. Sides of glass bodies are grooved to secure firm contact between the two materials. Properties of glass as a building material are described. Compressive and tensile strength are very high, modulus of elasticity is also great; due to internal tensions glass is very brittle. A number of vault constructions are described and experiences mentioned. Fire tests showed that glass and reinforced concrete act as a uniform body and have high fire resistance.—A. E. BEITLICH

Construction plant on the Beauharnois canal job. *Contract Record Eng. Rev.*, Nov. 5, 1930, V. 44, No. 45, p. 1384.—In construction of Beauharnois Power Development in Quebec concrete at the power house site is being mixed in 2 two-yd. mixers with all ingredients proportioned by weight. Aggregate is supplied by primary and secondary rock crushers having capacities respectively of 250 and 75 tons per hr. and a sand machine of 65 tons per hr. Four traveling cranes are employed in pouring concrete.—G. M. WILLIAMS

Shaking and stirring of concrete. *Zement* (Germany), Dec. 25, 1930, V. 19, No. 52, p. 1238-41.—In discussion of a paper by Trèves and addresses delivered by Freyssinet and Séailles on importance of shaking and stirring of concrete in molds, two methods are described: (1) Vibrators act on outside of forms and cause packing of concrete mixture. Apparatus designed by Bérenguier, which is called "Vibropyl," is very efficient. (2) Pervibrators are always placed in interior of concrete mass and transmit their vibrations directly. Great advantages of both methods are described in detail. Uniformity of concrete and its compressive and tensile strength are considerably increased. Difficulties, which were encountered in practice and remedies for such cases are illustrated.—A. E. BEITLICH

Encasing wood stave pipe with reinforced concrete. *Contract Record Eng. Rev.*, Nov. 19, 1930, V. 44, No. 47, p. 1435.—To permit landscape improvement of a park through which runs a 13 ft. 6 in. wood stave pipe line of the Hydro Electric Power Commission of Ontario the wood pipe has been encased in reinforced concrete shell which will permit removal of the wood-stave material at some later date. Reinforcing consists of an inner and outer ring of circumferential bars designed to take all stresses due to water pressure. Longitudinal reinforcement is designed to care for maximum temperature changes to which the pipe may be subjected. To fully support the pipe during construction the invert was poured in short saddle lengths of 6 ft. 4 in., carrying the covering up the sides to 60 deg. above bottom center line of pipe. Construction joints were made watertight with keys coated with emulsified asphalt. Concrete (16,200 cu. yds.) was delivered by transit mixers and discharged into chutes leading to bell mouths from which it was directed into place by tubes.—G. M. WILLIAMS

Concrete construction control and practice in the United States of America. H. GRIESEL. *Zement* (Germany), Dec. 4, 1930, V. 19, No. 49, p. 1163-7. —Factors which influence strength and general properties of concrete are: (1) Physical properties, shape, surface and purity of sand. (2) Natural composition of aggregates, petrographic character and influence of gradation on compressive and tensile strength. (3) Necessary amount of water in mixture and consistency. (4) Mixing and transportation, effect of temperatures and weather. Construction of bridge over Hudson River between New York City and Fort Lee N. J. is described as an example of construction control in United States. Results of laboratory tests given illustrate relations between concrete strength and w/c, influence of gradation on strength and most economic mixture which gives desired plasticity and guarantees necessary compressive strength. Tables and curves show sieve analysis and compressive strengths obtained under different conditions.—A. E. BEITLICH

Construction methods—Bridge River tunnel. *Contract Record Eng. Rev.*, Nov. 12, 1930, V. 44, No. 46, p. 1425.—Power project of British Columbia Electric Railway Co. involves boring a 2½ mile tunnel through Mission Mountains. Completed tunnel is horse shoe shape equivalent to 14 ft. 3 in. circular section. Lining requires approximately 34,000 cu. yd. concrete. In pouring the lining the invert or lower portion of the horse shoe section is poured and shaped by template together with short standing walls at each side. On this concrete floor a track is placed to carry a "jumbo" car equipped with a concrete gun and hinged collapsible steel forms, which rest on the base section and after being toggled into position support themselves as well as the weight of the concrete after placing. A pipe equal in length to the section being poured is inserted between form and rock at its highest point, is attached to concrete gun equipment and as car moves backward and forward concrete is forced through and allowed to flow down laterally into position. Concrete is compacted by means of small air hammers striking the outer form surface.—G. M. WILLIAMS

New construction of a quay in Bordeaux—Bassens (France). EMIL STRASSBERG. *Bautechnik* (Germany), Sept. 26, 1930, V. 8, No. 42, p. 643-6.—Reinforced concrete quay, about 8200 ft. long, to replace old structure on wooden foundations, consists of reinforced concrete piers connected by reinforced concrete arches. Piers are about 15 ft. high, 18 ft. wide and each rests on 31 octagonal reinforced concrete piles 15.7 in. in diameter and 62 ft. long. Part of piles have inclination of 1:4, 1:8, or 1:10. Each one carries load of 27.5 tons. Piers are 22.6 ft. deep and reinforced with steel rails. Arches have span of 27.9 ft.; they are 33.5 in. thick at centers and 55.1 in. near piers. Longitudinal reinforcements are placed in lower part of arches and in top part above piers. There is no connection between them. Piers are partly protected by granite facings. Mixture consisted of 772 lb. cement, 14.2 cu. ft. fine gravel and 28.2 cu. ft. of coarse gravel and had a plastic consistency. Detailed description of arrangement of site of construction and piling work is given.—A. E. BEITLICH

Vibro system of concrete piles. *Contract Record Eng. Rev.*, Oct. 29, 1930, V. 44, No. 44, p. 1362.—Vibro system of concrete piling involves driving into the ground a plain steel tube with a cast iron conical shoe, placing reinforcement in the tube if desired, and filling the tube with concrete after which the tube is removed. Operations of driving and with-drawing tube are performed by same steam hammer which requires use of a comparatively light supporting frame. The supporting frames are built in sections and used in heights of 50 and 64 ft. for making piles 34 ft. and 45 ft. long. Cast shoe is placed in position on ground surface and hollow cylindrical shell or tube set in position and fitted to shoe to make a water-tight joint, after which it is driven to proper bearing. Hammer blow is transmitted to tube through a metal covered wooden driving cap which fits into a cast steel helmet which in turn is welded on to a steel casting which rests on the top of tube. If reinforcement is used, the hammer and helmet are raised and the fabricated metal lowered into position. Concrete is placed through an opening in the side of the steel helmet at such a rate that the cavity below ground level is full when the tube has been withdrawn 1/3 the distance. In withdrawing the tube after each upward stroke of the hammer the tube is permitted to descend about one half the distance which it is raised, thereby ramming and compacting the concrete and thoroughly filling the space occupied by the walls of the tube. This vibration tamping action results in the formation of corrugations on the pile surface which are claimed to increase bearing power. A two-ton, single acting steam hammer is used. In average ground the bearing power of 32 ft. Vibro pile is said to be about 150 tons.—G. M. WILLIAMS

Construction of Lacroze subway railroad system in Buenos Aires (Argentina). ALOIS POLLAK. *Zeitschr. Ostr. Ingenieur und Architekten*

Vereins (Austria), Nov. 21, 1930, V. 82, No. 47-48, p. 401-3.—Second subway line, built by Ferrocarril Terminal Central de Buenos Aires, connects north western part of city with center and serves as freight line during night hours. Total length of this 15 million dollar project is 22,000 ft., 12,400 ft. of which was built in open excavation. Tunnel, 1394 ft. long was constructed underneath Maldonado river. Latter was provided with reinforced concrete floor. Reinforced concrete predominated in entire construction. Total of 157,000 cu. yds. of concrete and 7275 tons of reinforcements were used. Inner width of single tunnel is 13.39 ft. and of twin tunnel 28.54 ft.; tunnel is 19.36 ft. high. Passenger stations are all of similar design, 426.5 ft. long and from 47.6 to 68.9 ft. wide. Ventilating shafts are placed every 426.5 ft.—A. E. BEITLICH

Chicago open-well method. W. J. NEWMAN. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 306-8.—The Chicago open-well method, devised by General William Sooy Smith about 40 years ago, is well adapted for penetrating blue clay of the Chicago region to hard limestone that lies as deep as 130 ft. below surface. Clay is stiff and can be excavated in 3 to 6 ft. sections and lagged with 2 or 3 in. beveled-edge lagging held by two metal rings on the inside. Excavation is by hand and circular buckets about 2 ft. high and 20 in. in diameter are hoisted with an electrically operated niggerhead winch. Concrete is placed by pouring directly into the well. The top 4 ft. of caisson is usually reinforced with hoops and vertical rods and mixtures commonly used have been 1:2:4 or 1:1:2 depending upon design requirements. The rings and lagging are often removed ahead of concreting. In blue clay the hole is usually dry but the method must be varied when water-bearing seams are encountered. Methods for meeting different aspects of water problem are outlined. Recently rotary excavation machines have been used satisfactorily for caisson work of Chicago type.—H. J. GILKEY

Underground construction. "Grundbau." M. BENZEL, 1930, B. G. Teubner, Leipzig and Berlin (Germany), fifth edition, 238 illustrations, R. M. 4.40. Reviewed in *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Dec. 5, 1930, V. 82, No. 49-50, p. 425.—First part deals with investigation of underground by means of test piles and drilling. Then excavating and different methods of pilings are described. Coffer dam and caisson jobs are illustrated. Third part shows protection of excavations against water and frost. Descriptions of modern tools and machinery are given in detail.—A. E. BEITLICH

Use of caissons in St. Louis sub-soil. S. W. BOWEN. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 309-311.—St. Louis bedrock consists of limestone at a usual depth of 50 to 80 ft. Open concrete caisson construction is quite successful in foundation work. A common outside diameter is 8 ft. with 9 in. walls although both vary. The shell is reinforced against both outward and inward pressure. Excavation may be accomplished with a dredging bucket, orange-peel bucket or by hand. No metal cutting edge is used except where boulders or other obstructions are found. Various loading devices are used for keeping the caisson properly aligned and outside lubrication with water jets is sometimes required. A moderate amount of shooting may also be employed near the base of the caisson. When quicksand or other water-bearing strata are encountered, pneumatic methods may be used by placing an air lock on top of the shell. After caisson has been properly grounded and rock cleaned the shell is filled with concrete somewhat leaner than that of which the shell is made. Buildings such as the Statler Hotel, Lennox Hotel and Civil Courts Building, are supported on foundations of this type.—H. J. GILKEY

Yearbook of the German Society of Engineering. "Jahrbuch der Deutschen Gesellschaft fur Bauingenieurwesen." S. BAER. 1930, V. D. I.-Verlag, Berlin (Germany), V. 5, 216 pp. R. M. 12.00. Reviewed in *Zeitschr. Ostr. Ingenieur und Architekten Vereins* (Austria), Dec. 19, 1930, V. 82, No. 51-52, p. 438.—Newest developments of construction methods are

described. Special consideration is given to construction of large storage houses, mining and marine structures. A list gives short descriptions of 310 great German and Austrian construction jobs completed in 1928 and 1929.—A. E. BEITLICH

Twelve month construction. JAMES S. TAYLOR. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 322-325.—The analysis includes a consideration of relative costs and other pertinent factors for the several types of construction. The usual technique and suggested precautions of preheating materials and use of salamanders are included for concrete. There is also a warning against fire risks and too rapid application of heat. Conclusion is that 12-month construction has proved its soundness and its right to united support.—H. J. GILKEY

Winter construction. "Mitteilungen ueber das Bauen im Winter." FRITZ EISEMANN. Kalk-Verlag G. m. b. H., Berlin W62 (Germany), R. M. 0.40. Reviewed in *Zement* (Germany), Jan. 15, 1931, V. 20, No. 3, p. 64.—It is shown that winter construction can be made successful in many construction jobs by considering only few precautions and with only small extra costs. Small book treats subject from the economic viewpoint.—A. E. BEITLICH

Pre-cast concrete electrolytic tanks. HECTOR FARAH. *Canadian Eng.*, Dec. 9, 1930, V. 59, No. 24, p. 691.—Concrete has supplanted wood in the manufacture of 1216 pre-cast reinforced concrete tanks for the electrolytic refining of blister copper at plant of the Ontario Refining Co. Ltd., Copper Cliff, Ontario. The concrete cells, 11 ft. 3 in. long, 3 ft. 6 in. wide and 3 ft. 9½ in. deep, inside dimensions of precast members with wall thicknesses ranging from 3½ in. to 4½ in. were made of a special concrete mix consisting of 10 bags of cement per cu. yd. with very little sand and crushed rock not over ½". All steel reinforcement is protected by not less than 1 in. of concrete to prevent short circuits. Reinforcement consisted of specially designed mats of ¼-in. wire and spaced with 1-in. concrete blocks. Interior surfaces were protected by a lead lining and the exposed concrete painted with asphalt paint.—G. M. WILLIAMS

Chicago and North Western establishes quality control of concrete. O. F. DALSTROM. *Concrete*, Feb., 1931, V. 38, No. 2, p. 19-22.—In 1928 railroad adopted new specifications using water-cement ratio as basis of design for mixtures, following in general those adopted by American Railway Engineering Association. Results have shown necessity for being thoroughly organized and equipped for testing, inspecting and controlling concrete from time sources of supply are chosen until product is in forms, to insure proper interpretation of specifications and instructions. Because of great difference in new specifications from old, copy of specifications was sent to each contractor before bidding; special set of instructions on design of mix to division engineers, contractors and inspectors to accompany specifications; instructions to inspectors covering methods to be followed in field and requirements regarding water-control equipment on mixer. List of testing equipment and places of purchase was distributed to insure use of correct equipment. All field equipment was found without adequate water control in first year. This condition was completely corrected in 1930. Automatic time control devices are required. Test specimens of every mix are made in pairs, numbered in consecutive order throughout entire job, odd-numbered specimen being for 7-day test and following even-numbered specimen for 28-day test. Copies of test reports are sent to engineer of bridges, division engineer, inspector, and contractor, to guide and to stimulate interest. Samples of aggregates are submitted to railway company laboratory for test and approval. Railway's engineer visits each job occasionally or on request from division engineer or inspector, to settle questions regarding specifications or materials and equipment furnished by contractor.—C. BACHMANN

The manufacture and placing of large masses of concrete. L. BONNET. *Summary Reports*, First International Congress for Concrete and Reinforced Concrete, Liege, 1930.—Special precautions are necessary in mixing large quantities of concrete that have to be carried a great distance before placing in the work, to prevent segregation. Moreover manufacture of concrete in large quantities demands perfected plant both for actual mixing and for proportioning. During extension work in Port of Antwerp interesting observations were made in regard to concrete made from Rhine gravel and sand. Tests showed that best proportions of sand and gravel to use in making large masses of concrete are as follows: (1) 10 parts gravel to 7 sand, when the size of the gravel does not exceed 1.18 in. and when lead is short. (2) 10 parts gravel to 7½ sand, when the size of the gravel does not exceed 1.18 in. but when lead is long. The same proportion can be used if gravel is coarse while lead is short. (3) 10 parts gravel to 8 sand when gravel is coarse and lead is long. The second part of paper describes installation for making concrete in extension works of Port of Antwerp.—EDITIONS LA TECHNIQUE DES TRAVAUX

Handbook for reinforced concrete construction. "Hilfsbuch fur den Eisenbetonbau." VICTOR HIETZGERN AND ARNOLD ILKOW. 1930, Julius Springer, Vienna (Austria), R. M. 5.80. Reviewed in *Zement* (Germany), Dec. 11, 1930, V. 19, No. 50, p. 1192.—Book is treatise of entire field of structural materials and deals with proper preparation and working in reinforced concrete construction. Book is devoted to use by contractor and designer.—A. E. BEITLICH

Economy of distribution towers for cast concrete in superstructure construction. "Die Wirtschaftlichkeit des Gussbeton-Foerderturmes im Hochbau." R. FINNERN. 1930, W. Kohlhammer, Stuttgart (Germany), R. M. 3.00. Reviewed in *Zement* (Germany), Nov. 27, 1930, V. 19, No. 48, p. 1146.—After showing historical development of concreting methods, author describes economical properties of distribution arrangements for cast concrete. Conditions are illustrated under which installation of towers is advisable. Different examples are given and discussed from an economic view point.—A. E. BEITLICH

Twelve-month construction. JAMES S. TAYLOR. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 322-325.—During last decade winter construction has greatly increased as compared with period before the World War. Some of the causes underlying the change are: (1) pre-war experience with winter construction was greatly multiplied by war-time undertakings, (2) twelve-month construction of many types has a sound economic foundation, (3) the problem affects so large a section of the community that it is of importance to many other lines of business as well as to the public generally. The process employed in the winter construction of concrete consists usually of heating the fine and coarse aggregates, heating the mixing water, protecting stock piles, and housing materials affected by moisture, as well as entire mixer and plant. The temperature of concrete when placed should be above 60°. Protecting concrete while placing and curing is more important in building operations than in bulk work such as bridge and dam construction. Relatively smaller section of a beam or column is more readily and seriously affected by freezing than larger mass of bridge abutment or section of dam. Bulk concrete also provides more heat in setting. It can be housed very cheaply because of its compactness. The housing of building construction is more expensive, but it is seldom necessary to house more than story under construction. The heating is usually done with salamanders.—D. E. LARSON

Use of caissons in St. Louis sub-soil. S. W. BOWDEN. *Civil Engineering*, Jan., 1931, V. 1, No. 4, p. 309-311.—In order to meet unusual foundation conditions existing in St. Louis, there has been developed, in recent years, a rein-

forced concrete caisson which can be sunk to rock by open-well method, using air locks only where quicksand and water are encountered in such quantities as to make its use absolutely necessary. These caissons are hollow cylinders whose inside diameter is usually determined by the size of bucket used in excavating. Walls are made of such thickness as to give the proper outside diameter for the load to be supported. An outside diameter of 8 ft. is frequently used with 9-in. walls. For smaller sizes, excavation is by hand or by small orange peel bucket. No metal cutting edges are used except where boulders or other obstructions are apt to be encountered. Reinforcement consists of sufficient metal, both vertical and horizontal, to prevent cracking of walls, and this is placed in both faces. The minimum reinforcement generally used consists of bars $\frac{5}{8}$ in. in diameter, 12 in. from center to center for the hoops, and 24 in. for the verticals. Where it is likely that air will be used, the reinforcement is designed to take the unbalanced internal pressure, using unit stress of 15,000 lb. per sq. in. for the steel.—D. E. LARSON

Construction joints in concrete. NORMAN DAVEY. Dept. of Scientific and Ind. Research Build. Research Station (England), *Special Report No. 16*, 74 p.—The disadvantages of improperly made construction joints are mainly lack of strength and adhesion at the joint, efflorescence at joints, disintegration due to freezing of water in joints, susceptibility to percolation of moisture, disintegration due to penetration of substances in solution and failure under action of heat. Laitance at joint which is detrimental to proper bonding is usually due to excessive mixing water or even excessive ramming causing segregation of aggregate. Scum, dirt, clay, oil or grease should also be removed. Consistency of concrete should be carefully controlled so that mix will flow sluggishly when tamped into position. Method of washing joints with soda has been tested and found to be in no way harmful, provided all trace of soda is removed. Chipping and wire brushing old concrete has given good results but age of old concrete appears to be of considerable importance. Portland cement may be weakened by chipping while concrete is still green (at 24 hrs.), while after concrete has thoroughly hardened there is a falling off of bond strength due to difficulty of chipping and greater differential shrinkage between new and old concrete. Aluminous cement gives lower bond strength at earlier ages owing to greater shrinkage. For rapid hardening cement, chipping or treating the surface with hydrochloric acid and in both cases grouting with neat cement gives 70 per cent efficiency while for aluminous cement, acid treatment gives better efficiency. Results of tests on joints with old concrete prepared with proprietary compounds are given, and in most cases good results are registered. For applying new concrete to prepared surface of old, a sufficiently plastic mix must be employed to allow it to enter all interstices. A slump of 2 in. is recommended as minimum, while too wet mixes should be avoided. Durability of joints appears to increase with age. For two-layer work upper courses should be laid on lower before it has appreciably hardened. It is found that high adhesive strengths with a joint give watertightness. Aluminous cement concrete does not adhere so readily to rapid hardening types of cement as to ordinary portland cement. Joints in foundation rafts and footings should be cast to their full depth in one operation if possible. Any joints formed should be normal to the compressive stresses. Columns should be cast up to point just below the soffit of beams and left to set before beam and top of column are poured together. Beams may be stopped best at middle thirds, joints at points of excessive shear being avoided. Slabs should not have a horizontal joint and are best stopped at middle thirds.—JOHN E. ADAMS

Progress in reinforced concrete super structure construction during the year 1929. WILHELM PETRY. *Report 33rd main meeting German Concrete Association*, March 17, 1930, p. 142-92.—Important changes were made in preparation of sand and gravel for concrete by producing a greater number of gradings and using better proportioned mixtures, which fact resulted in

considerable increase in compressive strength. Many valuable experiences were obtained in winter construction methods during severe cold weather periods of winter 1928-29. Modern construction methods and improved equipment make winter jobs economic. Great progress was made in construction with sliding forms; system Heine was invented and used for erection of two monolithic chimneys (459.4 ft. high with 20 ft. inner diameter at top), built for power station in Schwandorf (Germany) (cf. O. Hoffmann, *Zement* (Germany), Aug. 28, 1930, V. 19, No. 35, p. 828-34) in a period of only 3½ months. About 8.2 ft. per day were concreted. Six silos were built for Wicking cement plant in Neuwied (Germany), which are 65.6 ft. high and 26.3 ft. in diameter; walls are 7.9 in. thick. System Rohmeyer was used for construction of grain silo in Duesseldorf (Germany), which consists of 10 circular cells with diameters of 26.9 ft. Complete winter structures are 4 cement silos with 8800 tons capacity in Blaubeuren (Germany). Work was started in Nov., 1929, concrete was placed daily and work was completed in 5 weeks, with interesting construction details. Torkret method for concrete roofs saves much time and labor. Arrangement of site, transportation of materials and use of newest machinery made construction of office building Sprinkenhof in Hamburg (Germany) a full success. Two towers distributed about 235 cu. yards of concrete (in 10 hr.) daily. A new type of concrete pump was used with great advantage for number of structures (cf. W. Haevernick, *Bauingenieur* (Germany), Feb., 1930, V. 11, No. 7, p. 100-2; *J. Amer. Conc. Inst.*, Sep., 1930, V. 2, No. 1, Abstr. Sect., p. 18; Heidorn, *Bauingenieur* (Germany), May 30, 1930, V. 11, No. 22, p. 381-4). In several office buildings, skeleton structures, engineering efficiency gave excellent results. Of special interest are construction of City Hall in Ruestringen (H. Kuball, *Der Bauingenieur* (Germany), May 16, 1930, V. 11, No. 20, p. 349-52), buildings of Englehardt brewery (Herbst, *Zement* (Germany), Aug., 14, 21, 1930, V. 19, No. 33-34, p. 776-9, 800-4, *J. Amer. Concr. Inst.*, Nov. 1930, V. 2, No. 3, Abstr. Sect. p. 78) and warehouses of Merchants Corporation in Barmen (*Zement* (Germany), Oct. 30, 1930, V. 19, No. 44, p. 1039-41). Industrial structures, built during 1929, include several large factories, storage houses of nitric acid plant and coal house of a mine. Results of tests of Austrian Government concerning use of high quality steel for reinforcements of concrete columns are included.—A. E. BEITLICH

Special carfloat used to distribute bulk cement. (See MATERIALS—CEMENT.)

Structural design and construction of concrete improved in 1930. (See ENGINEERING DESIGN—MISCELLANEOUS.)

ROADS AND PAVEMENTS

Concrete road junctions. R. A. B. SMITH. *Concrete Constr. Eng.* (England), Jan. 1931, V. 26, No. 1, p. 35-41.—In description of construction of concrete road junctions, order in placing concrete for parts of junction is outlined and illustrated for different types of junctions. Diagrams show different methods of placing construction joints. The simple case of one road meeting another at right angles is first considered. For two roads intersecting at right angles six arrangements of joints are given. For three roads meeting in which the roads have different widths a special arrangement for junction is given.—JOSEPH MARIN

Nation constructs 10,200 miles of concrete roads in 1930. *Concrete*, Jan., 1931, V. 38, No. 1, p. 13-14.—With December figures partly estimated, total yardage of concrete pavements, including roads, streets and alleys, should be about 144,000,000 sq. yd. in 1930, or about 3 per cent over 1929. Trend toward greater use of high grade equipment is seen in fact that 32 states

now require machine finishing of concrete pavements, compared with 26 states a year ago. Sixteen states now demand definite 28-day strength, compared with 13 states a year ago. Definite water-cement ratio is specified by 24 states, compared with 17 a year ago; 29 specify a minimum quantity of cement per cu. yd. of concrete. All states now specify a minimum mixing time, ranging from 50 seconds to 1¾ minutes. All except two require attachment of timing device to control time of mixing, and all except one require measurement of mixing water. Cross-sections of concrete highways are now required to have some type of thickened edges in all but seven states.—C. BACHMANN

SHOP MANUFACTURE

Testing of artificial stone, especially concrete block. R. AMMON. *Chem. Techn. Rundschau* (Germany), 1930, V. 45, p. 157-9.—Experiments were made to determine weight per cu. ft., specific gravity, porosity, absorption properties, hardness, durability and resistance to abrasion of several types of artificial stone and concrete block.—A. E. BEITLICH

Recent noteworthy executions in cast stone. *Betonwerk* (Germany), Aug. 30, 1930, V. 18, No. 35, p. 491.—A description of recent noteworthy executions in cast stone includes that of a large monument, several pieces of garden sculpture, tombstones and a small building illustrated. Each item of execution is analyzed in detail, in a manner to indicate the kind of cast stone, how made and finished. The name of designer in each case is indicated.—HERMAN FRAUENFELDER

Profitable manufacture of concrete building units. FRED A. SAGER. *Concrete*, Feb., 1931, V. 38, No. 2, p. 27-31.—In working out uniform production rate and scheduling output, year's business is analyzed. Based on estimates of use, stock for new 2 by 4 by 8-in. brick was arbitrarily set at 30,000 units for first year and included with the five major items of production of previous year. Total stock Jan. 1, was 70,000 equivalent 8-in. units, made up of quantities as determined from table given for five major items and 30,000 brick. Plan is to increase production to 30,000 units per month for most of the year, allowing for severe cold weather. Estimate of future year's business is on data of three or more past years, when records of years considered are shown by curves, continuation of which in next year serves as basis for that year's production. As year progresses, actual deliveries running ahead or behind estimated deliveries will be indicated and program altered accordingly. Items to be produced in any month will be determined by knowledge of business ready for delivery or in immediate prospect. For ready reference, records of manufacture, sales, and stocks are desirable in the form of diagrams or graphs, which can be projected into the future.—C. BACHMANN

Manufacturing and selling problems occupy products industry. *Concrete*, Feb., 1931, V. 38, No. 2, p. 13-15.—Continued use of concrete masonry and back-up units in large buildings, sustained interest in light-weight aggregates, development of use of colors, and growing attention to manufacturing and selling problems are some of outstanding developments in concrete products industry of 1930. Causes of shrinkage cracks in masonry walls are definitely determined. Cracking can be avoided if units are completely cured and air-dry before being used. Research associate at Bureau of Standards will inaugurate research program on cinder concrete building units covering a number of years. Progress has been made in New York with development of light-weight aggregate by sintering ashes and cinders from low-pressure boilers and other sources from which cinders, in raw state, are not suitable as aggregates. Improved design has made light-weight unit possible in some

cases where ordinary aggregate are used. Vibrating equipment is being used, especially in cast stone, concrete pressure pipe and drain tile manufacture. Use of color in cast stone and ordinary products is receiving increased attention and manufacture of concrete burial vaults is in more satisfactory condition. In new construction method, concrete masonry units, laid up as dry masonry, are "welded" by cement gun which shoots mortar into joints and coats surface. New specialty is metal-faced light-weight concrete slab or block for exterior or interior trim using any commercial metal as facing material.—C. BACHMANN

Spun concrete and reinforced concrete pipes., ERWIN MARQUARDT. *Bautechnik* (Germany), Sept. 16, 1930, V. 8, No. 40 p. 587-602.—After discussing historical development author explains fundamental principles of spinning process. Movement of materials in mold and necessary speed of rotation are illustrated by a number of mathematical equations. Some separation of aggregates and cement is always caused by centrifugal force, coarse parts being accumulated in outer portion of wall while lighter parts and cement are forced to interior. Following means for prevention of separation are advised: (1) Mix should not be too wet; plastic concrete has best consistency. (2) Aggregates should have rough surface and compact form, (3) Aggregates should be of as similar petrographic character as possible. Gradings over 0.6 in. should be avoided. (4) Manufacturing of pipes can be carried out in different layers with adjusted speed of rotation. Different manufacturing processes now in practice in United States and Germany are: (1) Dyckerhoff and Widman in Dresden (Germany) make pipes about 50 ft. long with inner diameter from 3.8 to 5 ft. They are reinforced with cylindrical wire cages with one or two spiral windings. Pipes are suitable for pressure lines under low heads. Belljoints connect pipes with small diameter while spun precast collars, reinforced with 2 spirals are used for larger sizes. (2) A high quality pipe for high pressures which is absolutely watertight is a steel sheet pipe covered externally and internally with layers of dense concrete. Spiral windings are wound first on special machine and then tightly placed inside and outside of steel cylinder. Outer coating is made of high early strength cement and placed in standing form while inner layer is spun after mounting steel form on driving wheels. Mixtures range from 1:3½ to 1:4. After spinning is completed (about 20 min.) excess water which is squeezed out is removed. Pipes are taken out of forms after 24 hours and stored in yard being kept wet by sprinkling for several days. Transportation, placing and jointing are described. (3) Hume process widely used in Europe and United States, is divided into 2 distinct periods. Forms are rotated first at slow rate of speed (200 to 300 r. p. m.) which forms a dense layer of uniform thickness in wall of pipe. Excess water is drained and interior surface is smoothened with a round steel rod during second spinning period (550 to 700 r. p. m.). Forms and pipes are carried to steam kilns and cured from 8 to 12 hr. with low temperature steam. Further storage is in yard. Joints are made with collars and hemp packings. Inside joints and one outside joint between collar and pipe are made in field. (3) Pipes of Vianini type are usually made in France. Molds do not rotate on wheels but are fastened between 2 side discs which movement is claimed to be free from vibrations. Different types of joints are illustrated. (5) Lock Joint Pipe Co., Ampere, N. J., manufactures pipe from 1.3 to 9 ft. in diameter for high heads. Longitudinal reinforcing rods are tied to wire cages by hand or by welding. Ingenious design of joints makes placing and jointing very easy. (6) Main feature of system by Moir and Buchanan is special feeder which at the same time secures uniformity of wall thickness. Pipes are of very dense structure. (7) Short description is given of several asphalt coated pipes. Last part discusses properties of spun concrete pipes such as strength, static tensions, water impermeability, resistance against mechanical abrasion and chemical influences, hydraulic capacities and economy. —A. E. BEITLICH